# SCIENTIFIC AMERICAN MONTHLY

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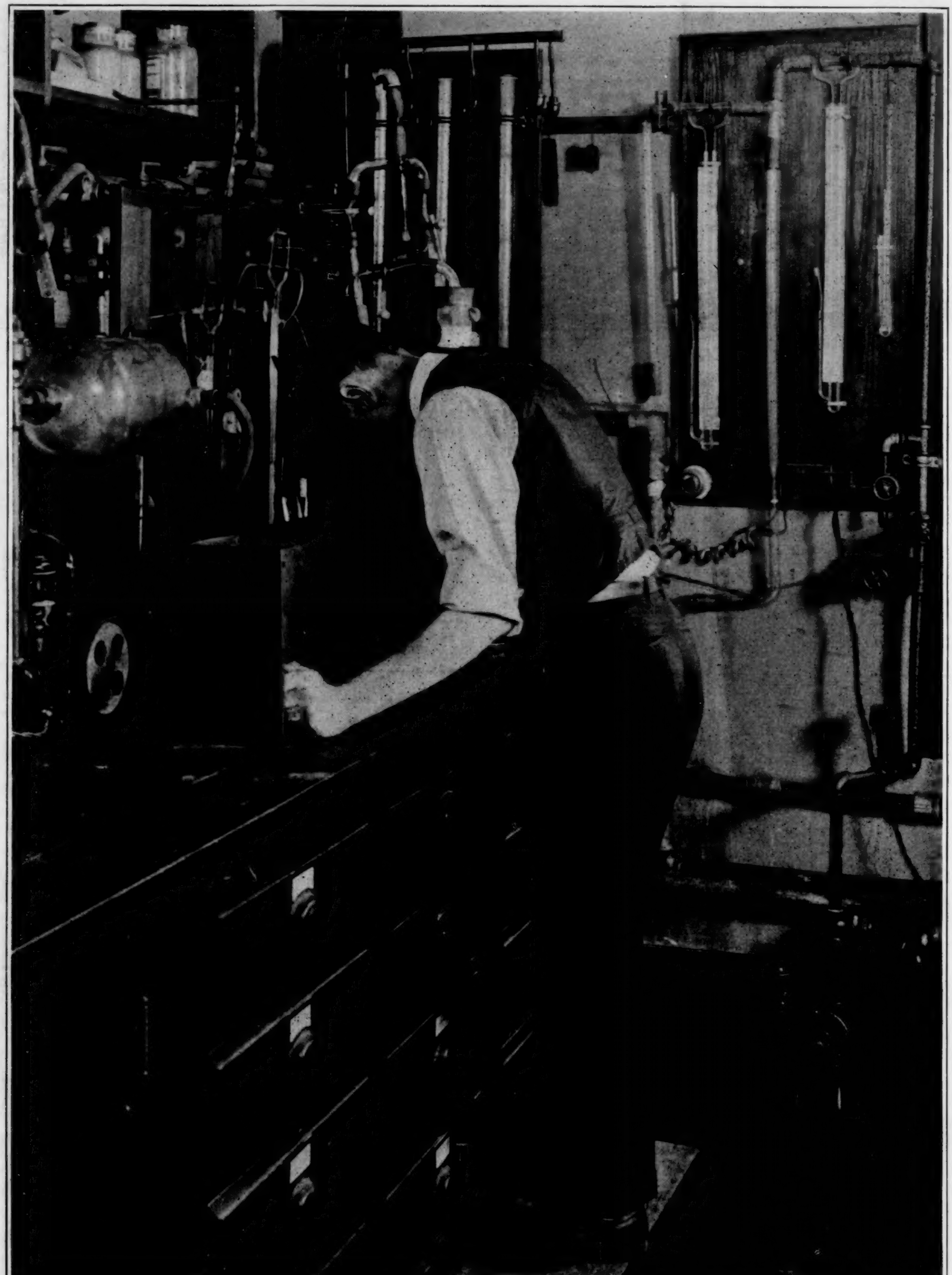

PEACE-TIME USES OF THE GAS MASK—TESTING SUGAR TUBES WITH TOBACCO SMOKE (SEE PAGE 37)

# SCIENTIFIC AMERICAN MONTHLY

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## WINGED "SUBMARINES" FOR HIGH ALTITUDE FLYING.

Not content to dwell where Nature placed him, man has endeavored to burrow into the waters of the ocean and to penetrate into the higher reaches of the ocean of the air. By means of diving suits men have descended to a maximum depth of some 300 feet, but even a dive of 100 feet would be a serious undertaking for the average man. In the ordinary diving suit the pressure of the surrounding water is imparted to the air which the diver breathes, and, consequently, his lungs and his whole being are subjected to severe strains. The only method of descending into the ocean with any degree of comfort is to go down in a chamber in which the air is maintained at atmospheric pressure. This is possible in submarine vessels or in diving suits constructed of steel so as to resist the external pressure. However submarines so far built dare not descend to a depth of more than 200 feet; for below that depth the crushing weight of the water is liable to strain them severely if it does not completely crumple them.

In aerial navigation we are going through the same course as was pursued in the development of submarine navigation. Hitherto flights to extreme altitudes have been of the nature of aerial dives or brief excursions and the pilots who essayed these perilous expeditions have been equipped with oxygen breathing apparatus or oxygen masks which correspond to diving helmets. Fortunately the difference between air pressure at sea level and that at an altitude of five or six miles while considerable is in no way comparable with that of descending 300 feet into the depths of the ocean. Nevertheless even with aerial diving helmets we are unable to rise much above an altitude of six miles. It is true that the altitude record is 36,020 feet, made by Major Schroeder a few months ago, but there are only two others who have ever reached an altitude of more than 35,000 feet and even 30,000 feet has been reached by very few aviators.

A recent development consists in employing a special release valve automatically controlled by barometric pressure so that it will feed oxygen to the mask worn by the aviator in proportion as he requires it. However, even with such apparatus it is a question whether it could be possible for an aviator to rise to an altitude of, say, 40,000 feet. Laboratory experiments indicate that at a pressure corresponding to that height, the tension of the oxygen in the lungs falls so low that the tissues are unable to make use of it. Strange to say a certain amount of carbon dioxide is needed, not merely to dilute the oxygen but to increase the pressure of oxygen in the blood. Just how the carbon dioxide functions has not yet been determined, but it seems to be needed to aid the lungs in absorbing the required oxygen in rarefied atmospheres. Experiments have therefore been made with oxygen, in which a certain proportion of carbon dioxide has been mixed. However, even with this improvement, it is hardly likely that flights of extreme altitude will become very popular. Only hardy passengers, men with strong constitutions, would be able to take such flights. At best passengers would find the wearing of masks or "aerial diving suits" a decided nuisance.

It is not for the mere purpose of satisfying human ambitions that aerial navigators have tried to rise to high levels, nor is it with the purpose of exploring the upper strata of the atmosphere. Such explorations can be and are carried on successfully by means of sounding balloons equipped with instruments that record automatically the meteorological conditions encountered. There are material advantages to aerial navigation in rising to high altitudes. Head resistance is greatly reduced and much higher speeds are therefore obtainable; hence high flying is economical in time and fuel. Furthermore, there are prevailing winds at various altitudes which could be utilized by the aeronaut or aviator were he able to guide his machine at will to a level at which there was a current of air blowing in the direction of his course.

If diving suits fail us why not use "aerial submarines," that is, enclosed cars in which air at atmospheric pressure can be maintained?

By this means alone would it be possible for the average passenger to endure and enjoy sustained flight in an extremely rare atmosphere. He would be relieved of all the perils of high altitude conditions and would not experience the slightest discomfort.

This interesting subject was discussed in an article published in the January issue of this journal. On page 70 of the present number, there is an article by Dr. Guglielminetti which gives further information on the subject. He points out the advantages of this method of navigation in a rarefied atmosphere. The air pressure requisite even at extremely high altitudes would not be much greater within the car than in the atmosphere outside and a very strong construction for the car would not be necessary. Special oxygen tanks would not be required, as it would merely be necessary to pump into the car with a blower enough air to keep the pressure at the normal of sea level. A biplane has been designed with an enclosed car capable of carrying a large number of passengers. Special interest attaches to the chart which shows the range of travel of this aerial bus and its load capacity for various distances along lanes of travel running up to six miles above the earth.

It is more than probable that we shall soon see the "winged submarine" in service making long distant flights in remarkably fast time.

# Recent Discoveries Regarding the Stars

## The Motion, Brightness, Distance and Distribution of Stars and Spiral Nebulas

By John Candee Dean

SUMMER days draw us to outdoor life, and we find mild evenings very agreeable for star gazing, on clear moonless nights. As we stand under the great dome of the heavens, in whatever direction we turn, we see the light of far distant stars shining down upon us.

The ancient belief was that the stars were all about the same distance from the earth. They were thought to be fixed in the "crystalline heavens," a huge, hollow crystal sphere, with the earth at its center. The earth was supposed to be stationary, and the crystal sphere rotated once every twenty-four hours. We now know that the distances of different stars vary enormously.

Naked eye observations of the constellations indicate that the fixed stars have not changed their relative positions since the days of Homer. There has, of course, been a shifting of the sphere of the heavens due to precession, but with relation to the Milky Way, the constellations appear *not* to have changed in 2,500 years. When, however, they are examined with the telescope, it is found that the stars are moving at great velocities in various directions.

### STELLAR MOVEMENTS

The astronomer Kapteyn found that the average speed of stars is about 23 miles a second or seven billion miles a year. There are some high speed stars with velocities of 100 to 150 miles a second. These high velocities show that their motions are nearly in straight lines and practically independent of their mutual attractions. In spite of the speed of these "runaway stars," it would require nearly 200 years for the nearest of them to move a distance equal to the moon's apparent diameter. They are too small, however, to be seen with the unaided eye.

The motion of stars in the line of sight, that is, to or from us, is called radial motion, while motion at right angles to this, or across the sky, is called proper motion. The radial motion, or motion in line of sight, is determined by spectroscopic observations. If its distance is increasing, its lines in the spectroscope are shifted toward the red, and if the star is moving toward us its lines are shifted toward the blue, this motion is easily translated into miles. The proper motion of a star cannot be determined in miles unless its distance is known.

The theoretical fundamental of space is the ether which is frictionless, elastic, immovable, continuous and pervades all space. It is the medium which carries light. Light is not a substance, but is a wave motion of the ether. Several attempts have been made to determine the motion of the sun with respect to the ether, which is supposed to be stationary, but such attempts have failed. The sun with the whole solar system is moving in the general direction of the star Vega in the constellation of the Lyre. This point which is found to be five or six degrees from Vega is called the apex of the solar motion. The antapex is in the general direction of the star Sirius. That is, we are moving toward Vega and away from Sirius at a velocity of about 12 miles a second.

Interstellar space is estimated to be at a temperature of about 500 degrees below freezing. At a distance of 200 miles from the earth's surface this low temperature prevails. The absolute limit of cold is 523 degrees Fahrenheit, below the freezing point. This is called the absolute zero. Artificial cold within two degrees of this temperature has been produced in the laboratory. There is no air in space and the vacuum is nearly perfect. It is probably a more nearly perfect vacuum than can be obtained artificially, consequently the stars and planets move through space without friction. It must not, however, be assumed that there is no matter in space. The cosmic matter in space is so thinly diffused that it has practically no effect on light. It has been shown that less than 1 per cent of starlight is absorbed by traveling for thousands of years through space.

Moulton tells us that the large velocities of stars show that their motions are nearly rectilineal and practically independent of their mutual attractions, except when two or more pass near each other. It can easily be shown by the principles of celestial mechanics that mutual gravitational attraction of the stars cannot generate such enormous velocities. "There is no reason for assuming that the stars were originally at rest, and hence we are under no obligations to account for their motion any more than we are for their existence."

The nearest star visible to the unaided eye, in our latitude, is the Dog Star, Sirius. It is also by far the most brilliant of the millions of fixed stars of our universe. As we gaze at it we note other smaller stars near by. We call them smaller because they look small, but this is on account of their vastly greater distance from us. A star that shines with a faint light may be dimmed by distance and in absolute brilliancy may be many times brighter than the Dog Star.

### EXTENT OF THE MILKY WAY

The Dog Star is in the western edge of the Milky Way, a great belt of stars that encircles the earth. When a photographic plate is exposed, in the telescope, to the light of the Milky Way it is found to be packed with thousands of stars. The Milky Way is the very foundation of our stellar universe. It has been found that many of its stars belong to two great streams flowing in opposite directions which interpenetrate each other without interfering with their movements. Milton says:

> The Galaxy, that Milky Way
> Which nightly as a circling zone thou seest
> Powdered with stars,
> A broad and ample road, whose dust is gold.

It is impossible to express, in adequate language, the immensity of the Milky Way. It fills our minds with indescribable grandeur. This stupendous girdle is composed of millions of vast suns whose depths are beyond the reach of our largest telescopes. All visible stars belong to this great galaxy of stars. Its shape is supposed to be like a watch case. When we look at the Milky Way we are gazing through the longer diameter of the case which gives an impression of stars closely packed together, and when we look away at right angles to the Milky Way, we are looking through the shorter diameter of the case, and the stars appear scattered.

From what has been said, it will be seen that the Milky Way is a huge cluster to which our solar system belongs. It is found to be enormously larger than astronomers had previously supposed.

### STELLAR DISTANCES

Stellar distances are measured in light years. The progressive velocity of light is so great that we cannot form any mental conception of it. Light of all colors travels at the same velocity. It would pass around the earth about 450 times a minute, its speed is six trillion miles a year, and yet it may take as much as 200,000 years for light to pass through the limits of the greater diameter of the Milky Way. Among the objects of the stellar universe are globular clusters of stars. The total number of known globular clusters is sixty-nine. They belong to the general system of the Milky Way, but are not in the Milky Way. They are at remote distances from us varying from 18,000 light years to 300,000

light years. The best known globular cluster is that in the constellation of Hercules. It is just visible to the naked eye, but in a telescope of even moderate size is a splendid object, sparkling like a cluster of small diamonds. Its distance is estimated by Shapley at about 35,000 light years.

### STUDY OF GLOBULAR CLUSTERS

Within a few years our knowledge of the structure and extent of the stellar universe has been greatly extended, largely through the study of globular star clusters by Dr.

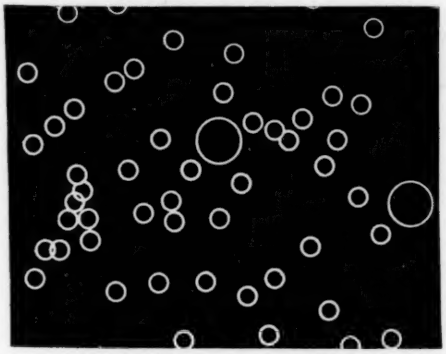


FIG. 1. SPECIAL NEBULAS IN A REGION SOME DISTANCE FROM THE MILKY WAY

There are 53 rings: at the center of each there is a nebula. Space covered is about equal to that of the full moon.

Shapley, of the Mount Wilson Observatory. He has discovered, by the study of certain stars which vary in brightness in the short period of one day, that they are about 100 times as bright as the sun. These short period Cepheid variable stars are found in the globular clusters and they are ingeniously used to tell the story of the distances of the clusters themselves. Those stars whose period of variation is four days are found to be 400 times as bright as the sun. Knowing their apparent brightness, and also knowing their real brightness, Shapley is able to compute their distance, and thus determine the distance of the star clusters. These distances are astounding. The great Hercules cluster previously referred to is 35,000 light years away and the remotest cluster observed is computed to be 220,000 light years away.

Our sun belongs to the fixed stars, and being near us, affords an opportunity by comparison, to determine the structure of distant stars. They are all gaseous bodies, and the spectroscope demonstrates that they are composed of the same elements as the sun. The sun is classed as a "G" star and is, therefore, below the average in temperature. In regard to size, it is also moderate. The Dog Star is estimated to be forty-eight times as bright as the sun. If we were as near to that star as we are to the sun, we would be burned to a crisp by the intense heat. The brilliant star Spica is 13,000 times as bright as the sun, while Canopus, a very bright star in the south polar sky, is 55,000 times as bright as the sun. Spica and Conopus are both about 500 light years from us. To express their distance in miles, write down three and add fifteen ciphers.

### MEASUREMENT OF DISTANCES

The distance of a star is determined by its annual parallax. The operation of measuring a star's parallax is considered the most difficult in the whole range of practical astronomy. No star has yet been found with a parallax as large as one second of a degree, and this large parallax is a microscopic distance on the circle of the telescope. The triangle would be equivalent to one with base of three inches and sides 60 miles long. Only a few of the very nearest stars have sensible parallaxes, therefore, we know the accurate distance of but few stars.

Such bright stars as Canopus, Betelguex, Deneb and Beta Centauri are so far away as to be practically without sensible parallaxes. Recently photography has been successfully applied to this problem with increased accuracy in the results of estimating stellar distances.

A still more recent and very promising method of finding the distance of stars has arisen from spectroscopic methods of predicting stellar magnitudes. This method is based on the discovery that the "ultimate magnitude" of stars can be found with surprising accuracy from the relative intensity of certain lines in their spectra. Knowing the ultimate magnitude and the relative brightness, their distances can be determined by comparison, with nearer stars whose distances have been found by their parallaxes. Comparison of distances computed by this method with the distances computed by parallactic methods are said to agree very closely. This remarkable discovery may in time enable astronomers to measure the visible depths of the universe. At present the weakness of the spectra of faint stars limits its application to the brighter ones.

It has been shown by the Harvard classification of stars that the older stars are the coolest and are also the swiftest in their movements. The fact is, that the entire universe down to the smallest atoms is in intense motion. From this it has been suggested that all matter is alive. That is, life is a property of matter. A wealth of evidence has been collected which proves that the atom is an organized planetary system of dazzling complexity in which electrons simulate the movement of the planets in our solar system. The negative electrons of the atom revolve around their positive nuclei, like planets around the sun. The planet Neptune requires 165 years for a single revolution around the sun, while the electrons of atoms complete their revolutions around their nucleus in the millionth or the billionth of a second. These electrons are thought to revolve in a series of concentric orbits, all in the same plane. If oxygen gas, at atmospheric pressure, could be magnified until each nucleus were equal to the mass of the sun, we would have the sidereal universe reproduced in which the mean distance between the atoms would approximate the mean distances between the fixed

FIG. 2. A TYPICAL SPIRAL NEBULA—MESSIER 51

stars. Thus in oxygen gas and other gases the sidereal universe is reproduced in miniature.

Since the forces acting in the atom are found to be electrical, may not the force acting in the stellar universe be electrical? Is not the force of universal gravitation electrical? Should not the universality of stars lead us to infer that the force of universal gravitation is an electromagnetic force?

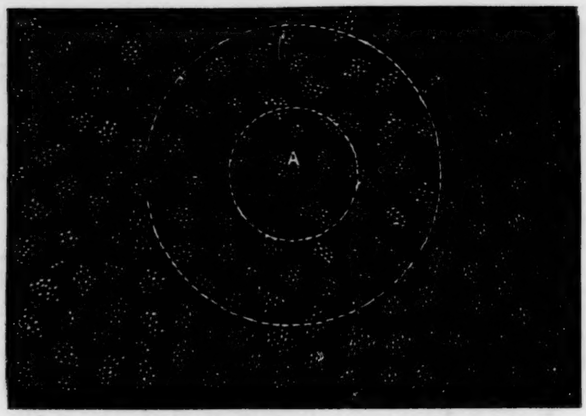



FIG. 3. SUPPOSED STRUCTURE OF THE UNIVERSE ACCORDING TO WILLIAM HERSCHEL

There are but two classes of objects seen in the distant heavens: stars and nebulas. The nebulas are divided into three classes, irregular, planetary and spiral. There are certain nebulous stars called the Wolf-Rayet stars. It is also thought that various black patches in the sky are caused by dark irregular nebulas. Only two bright nebulas are visible to the unaided eye, viz.: the great irregular nebula of Orion and the great spiral nebula of Andromeda. It is related that a sea captain in crossing the ocean discovered what he thought to be a comet, which he watched with interest during his voyage. On arrival at the port of Boston, he hurried to the Harvard Observatory to announce his discovery, but was there informed that he had been looking at the nebula of Andromeda.

This most beautiful spiral nebula appears to the naked eye as a hazy patch of light, and it requires a large telescope to bring out its beauty. With the three-foot Crossley telescope at the Lick Observatory several fine photographs of this nebula have been obtained. On a plate exposed in the Crossley reflector covering a portion of the sky, some distance from the Milky Way, in a space but little larger than that of the full moon, no less than 53 spiral nebulas are shown. A count of the small spirals on photographic plates, taken with the Crossley reflecting telescope at the Lick Observatory, indicates that in the whole heavens there are at least 700,000 of these small nebulas within reach of very large telescopes. No doubt, the 100-inch telescope at the Mt. Wilson Observatory will be able to show more than a million.

The spirals are never found in the Milky Way, they increase in numbers as the poles of the Milky Way are approached. Their speed of movement is higher than any other objects in the heavens, sometimes averaging several hundreds of miles a second. They generally have but two prominent arms winding out from their central nucleus. The latest and most sublime theory regarding them is that they are distant universes of stars. Prof. H. D. Curtis of the Lick Observatory says:

"On this theory could we be transported out into space a distance of hundreds of thousands or millions of light-years, to where the spirals are, and look back from that point at our own particular Milky Way, and stellar universe, it would perhaps appear to us as a spiral nebula."

On the theory that the spirals are separate Milky Ways, or "island universes," Curtis estimates their distance from us at from ten million to one hundred million light-years. He says, "It is certainly a wonderful, a brain-staggering conception, more tremendous even than any other of the mighty ideas of astronomy, that our own stellar universe may be but *one* of hundreds of thousands of similar universes."

The illustration Fig. 1 is from a photograph covering an area of the sky about equal to the apparent size of the full moon. The nebulas are at such vast distances that they are mere specks shown at the centers of the circles. There are 53 nebulas in this small area. Fig. 2 shows the spiral nebula called Messier 51. It is of a typical form with two arms leading out from the central nucleus and winding around it. Fig. 3 is from a drawing by Sir William Herschel made the latter part of the eighteenth century. At the center A is the star cluster of our galaxy, or our universe of stars; beyond and around it are numerous exterior universes of stars. It is remarkable that in Herschel's time these distant, so-called nebulas could not be seen and their existence was purely a matter of theory. Now through the use of our larger telescopes it is found that there is visible evidence to support the Herschelian hypothesis.

While the sun moves at a uniform rate and probably in a straight line the earth, owing to its motion around the sun, describes a huge spiral in space. Because the plane of the earth's revolution is inclined to the line of the sun's way, a variable motion of the earth toward the apex is produced. Referring to Fig. 4 the earth's motion toward the sun's apex is shown to be seven times as rapid at b as at d. At b the velocity is 21 miles a second, while at d it is only 3 miles a second. Fig. 4 shows the course of the sun and the earth

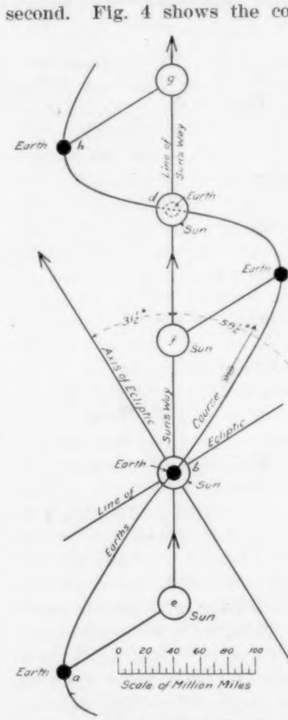



FIG. 4. MOVEMENTS OF EARTH AND SUN TOWARD APEX OF THE SUN'S WAY DURING A PERIOD OF ONE YEAR

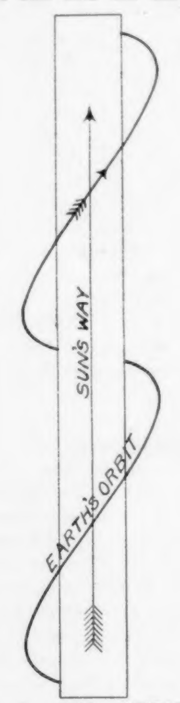



FIG. 5. THE SPIRAL COURSE DESCRIBED BY THE EARTH DURING A PERIOD OF EIGHTEEN MONTHS

during a period of one year. The first three months the sun moves from e to b, and the earth from a to b. The second three months the sun moves from b to f and the earth from b to c. The third quarter the sun moves from f to d and the earth from c to d. The last quarter the sun moves from d to g and the earth moves from d to h. Fig. 5 is another view showing the helical course through which the earth actually moves during a period of eighteen months.

# Is the Earth Expanding or Contracting?*

## Theory of a Gaseous Core Denser than the Solids Which Form Out of It and Incase It

By Hiram W. Hixon

*[In the* Scientific American Monthly *for April, pages 292 to 297 there appeared an article by Emile Bélot, Chief Engineer of Manufactures under the French Government entitled "The Ballistics of Volcanoes" in which the marine theory of the origin of volcanoes is defended. The author of the present article does not accept M. Bélot's arguments but holds to the theory that they are the result of a gradually shrinking planet. A letter by Mr. Hixon commenting on M. Bélot's article will be found on page 96.*—Editor.]

THE cause of elevation, folding, faulting and other changes in the earth's crust which raised what was once covered by the sea, in a former geological period to the land we live on, has been variously stated, but further examination has shown that the old hypothesis will not explain the observed facts.

It is not generally known what the cause of causes is, but if the argument which follows is correct then it must be local and regional reduction of density which causes elevation and local and regional increase of density which causes subsidence. Unloading or erosion accentuates elevation, and loading by deposition of sediments accentuates depression, but neither is the ultimate cause of either elevation or depression. The Grand Canyon area was a region of depression for a long geological period, and then it became a region of elevation. The unconformities show (Fig. 3) that these conditions have been reversed three or more times on a gigantic scale, and many times on a minor scale. In Dutton's "Monograph on the Tertiary History of the Grand Canyon" his analysis of the process by which the Canyon was cut is that the river was there first, and the plateau rose in the path of the river. This is obviously true, because rivers do not run over plateaus 8,000 feet high and cut canyons through them, when there are regions of less elevation in which they can flow. We are therefore confronted with the necessity of finding a competent cause for the elevation from below sea level to an altitude of 18,000 feet above sea level, of a dome in the earth's crust 150 miles in diameter. There have been removed from the Grand Canyon area, according to Dutton, 10,000 feet of strata

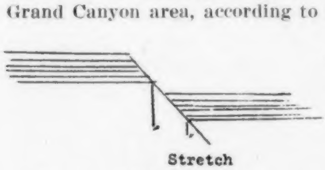



FIG. 1. NORMAL FAULT

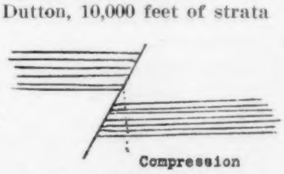



FIG. 2. REVERSED FAULT

The normal fault is called normal because it is the dominant type, and it is impossible to produce this type by contraction of the hot interior of the earth acting on the cold crust, for slumping down must be preceded by elevation.

of various geological ages overlying the carboniferous, which is exposed in the rim of the Canyon at present at an altitude of 8,000 feet in the north wall. Loading furthered depression of the sedimentary series, but when deposition ceased, the surface was still at or below sea level, and erosion could therefore not be the cause of elevation. The elevation is greatest where erosion has gone deepest, which is in the Canyon itself. The proof of this is that all the surface drainage is away from the Canyon rim and one is obliged to go up hill to the Canyon. This is due to the fact that the removal of the immense weight of material in the cutting of the Canyon has caused an increased uplift over the area near the Canyon and reversed the dip of the strata as in an anticlinal.

But the elevation has been great in regions remote from the Canyon, so that the cutting of the Canyon cannot be the cause of more than local adjustment to anisostatic balance. This isostatic balance is world wide as well as local, and the continents and islands which stand above the ocean bottom do so simply because the sub-crustal material beneath them is less dense than beneath the more depressed parts of the earth. The rocks composing the stratified series in these elevated regions testify to the fact that they were deposited below sea level, and we are, as in the case of the Grand Canyon area, obliged to explain how the immense weight of the continental masses have been lifted to their present positions.

The contraction hypothesis is incompetent to explain these changes of altitude because of lack of strength in the crust, as shown by Woodward and other investigators. Calculations were made on the strength of earth domes, taking into consideration strength of materials and weight, and it was found that when considered as a dome of the radius of the earth, twenty-five miles thick, and of material equal to the crushing strength of granite, that such domes would not sup-

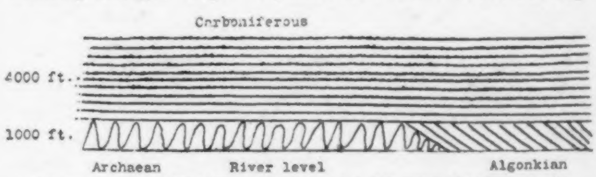



FIG. 3. DIAGRAMMATIC ELEVATION OF THE NORTH WALL OF THE GRAND CANYON OPPOSITE BRIGHT ANGEL TRAIL

Two great unconformities, each of which marks a period of erosion of a land surface subsequently submerged and deeply covered with sediments. The region was later elevated and a dome or mountain range eroded off, and this repeated three times.

port one five-hundredth part of their own weight if they were one hundred miles in diameter. Obviously, if domes of such small diameter are not self-supporting, then domes of continental size cannot be, and the crust must at all times be supported by the material below it.

If it is in isostatic balance at all times, and varies in altitude from one geological age to another, then the only solution of the problem is that a part of the subcrustal material varies in density between these dates.

The cause of the variation in density is now the chief concern, and it is necessary to depart a considerable distance both in time and subject to explain that.

To begin with, it is necessary to define several things:

1st—Critical temperature is the temperature above which matter is always in a gaseous condition regardless of pressure.

2nd—Gas is matter above its critical temperature.

3rd—The sun is above its critical temperature as a whole and therefore gaseous throughout, and in the central portion gravitational compression makes gases of a greater density than the solids that may form out of them when cold.

4th—Gas of greater density than solids is still gas, and subject to the laws governing diffusion, and will support or float a crust of solids and may be called solid gas.

5th—According to Graham's law of the diffusion of gases in a mixed body of gases, each gas occupies the whole space as if the other gases were absent.

6th—In a sun or planet in an incandescent condition it must follow, if these laws be true, that each gas will diffuse clear through the whole planet irrespective of density, and occupy the space where gravitational compression has made the density greater than the solids which will form out of them at the surface when cold.

*Reprinted from *Popular Astronomy*, Vol. XXVIII, No. 5, May, 1920.

7th—Rigidity is a property of matter that resists deformation to sudden movement and is relative to that movement.

For example, the earth as a whole is said to be as rigid to the tidal movement as a sphere of steel, but it yields to centrifugal force, and is of greater equatorial than polar diameter. It also yields to reduction of density as shown, and the isostatic balance is preserved by yielding to small forces long continued, like loading and erosion.

Rigidity is a property of cold matter, as we are used to it, that is lost when the temperature is much increased whether fluidity is reached or not, as for example: A bar of steel heated in a forge is rigid on the cold end and soft on the hot end.

Therefore, an increase of temperature of 1 degree Centigrade for each 100 feet of depth will cause a plastic condition or a zone of rock flowage long before the melting temperature is reached in a solid globe.

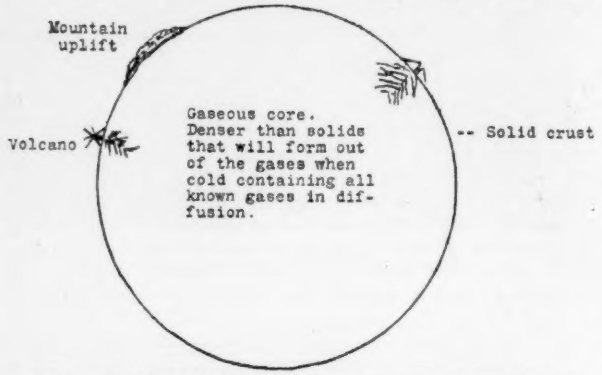



FIG. 4. DIAGRAMMATIC SECTION OF THE EARTH TO ILLUSTRATE THE THEORY OF A GASEOUS CORE DENSER THAN THE SOLIDS WHICH FORM OUT OF IT

The core contains some of each of gases which were originally in the gaseous planet sun, and are held there by the power of diffusion until liberated by the cooling of some of the elements below their critical temperatures. These elements become solids because the gravitational compression raises the fusion point to the critical temperature. The average density of the earth is about 5.6, water being 1; so that at the center the density must reach 10 or more. At the surface the cold material has an average density of 2.7, and pressure increases at about 3 tons per square inch per mile of depth. The rate of increase, increases with the depth and at the center of the earth is about 25,000 tons per square inch. The crust is much thinner in regions of volcanic activity and the increase of temperature with depth is much more rapid than in regions covered with thick beds of sedimentary rocks. The average, so far as known, is about 1°C. for 100 feet of depth, or about 50°C. per mile of depth, which would give 5,000°C. at 100 miles if the increase were uniform, which it probably is not. If 5,000°C. is reached at 100 or 150 miles of depth that would be high enough to volatilize all known substances.

The most recent information regarding increase of temperature with depth has been obtained from a well drilled to a depth of 7,580 feet at Valley Falls, W. Va. The temperature near the top of the hole was 52° and at the bottom 170°F. This increase is at the rate of 1.56°F. or .865°C. per 100 feet, and is also the greatest depth to which a bore hole has been drilled.

As a result of rock flowage without melting, all cavities are closed at a mile or less of depth, and in deep mines it has been found that surface waters do not go much below two thousand feet, and below that the workings are dry. Notwithstanding this fact, lavas which come from great depth are porous and full of gas and steam when they issue from the craters, and it is now known that gases, a considerable portion of which is steam, 75 per cent by analysis in the report of the observatory on Kilauea for July, 1919, are the sole cause of the elevation of the lava in the craters and the craters themselves, and all the other phenomena known as volcanic action, and as I shall show, also of geysers and hot springs.

Chamberlain's postulate of a cold earth developed from planetesimals is not in accord with the observed fact that the moon, with only one-eighty-first part of the mass of the earth was formerly molten, as shown by the crater rings which are visible on its surface.

Assuming an incandescent condition for the earth before it had a crust, we have the origin of the gaseous core or solid gas, with rigidity corresponding to compression and containing some of each of the gases which were in the original gaseous planet.

The gases of low critical temperature will continue to be held in the gaseous core by the power of diffusion so long as the temperature is above the critical point for all, and as the mass on the outer surface of the gaseous core loses heat and falls below the critical temperature of *some* of the elements, they pass from the gaseous to the solid condition because the gravitational compression has raised the fusing point to that of the critical temperature, eliminating the fluid condition. The gases of low critical temperature such as Nitrogen, Hydrogen, Co, $Co_2$, $So_2$, etc., can no longer remain in diffusion with solids, and they work their way up through the zone of solid flowage to the bottom of the zone of fracture by some process similar to osmosis; by which they constitute an integral part of a non-porous medium with additions from below and relief from above. They act as carriers of heat from the zone of critical temperature to the focus of volcanic fusion, and when sufficient gases and heat have accumulated break through to the surface and cause the various physical phenomena known under the head of volcanic action (Fig. 4).

They rise uniformly from the zone of critical temperature or solid gas, but owing to long established channels do not reach the surface except in localities of volcanic activity. Their first effect is to reduce the density of the rock matter, which they fuse by their contained heat, and this reduction of density causes elevation at the surface of the solid crust in the same manner that the leavening gases cause the elevation of the surface of a loaf of bread: Example, the Black Hills, S. D. When sufficiently accumulated, the elastic pressure of the gases pulls the zone of fracture apart, and the gases rush into the fracture carrying along the fused rock matter as a dyke or sill, which may or may not reach the surface and result in volcanic action. Dissected craters are shown to be located above dykes, as witness the one on the Canyon rim at Vulcan's Throne, Grand Canyon (Dutton). Lavas are local fusions of rock by volcanic gases and vary widely in composition from the same crater at different eruptions.

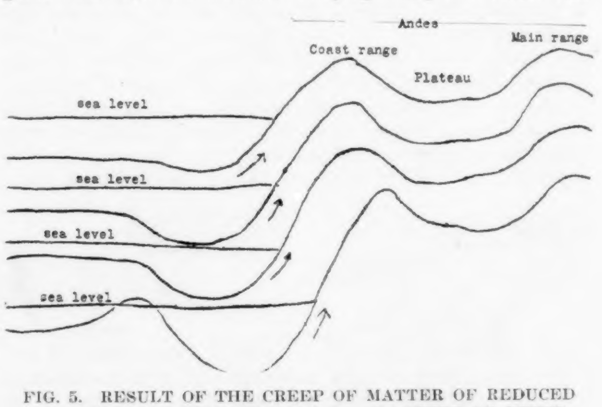



FIG. 5. RESULT OF THE CREEP OF MATTER OF REDUCED DENSITY BENEATH THE ZONE OF FRACTURE ON STEEP SLOPES FROM DEEP SEA TROUGHS TOWARD HIGH MOUNTAINS

The sea trough is deepened while the sea beaches and mountains are elevated periodically at time of sudden movements and earthquake. The submarine ridge to the left of the trough will in time become a third range of mountains and the elevated trough will be filled with the wastage of the mountains in the same manner as the plateau surrounding Lake Titicaca has been filled. The festoon of parallel ranges of mountains shown on maps are thought to have been formed in this manner.

The matter of reduced density below the zone of fracture tends to seek a higher level and displace matter of greater density. This results in the phenomenon known as stoping or thinning of the zone of fracture, and is characteristic of volcanic regions, and is the means by which craters are bored through horizontal bedded strata not otherwise disturbed, as for example, the diamond pipes in South Africa and Devil's Tower in South Dakota. This creep of rock matter saturated with gas from regions of great depth is influenced by the heat gradient or isogeotherms; and in a region where deep ocean areas border on the land, and high mountains are near the sea, it results in sudden upward movements which carry the crust blocks in a sudden lurch, just like a land slide only reversed in direction. In this way the ocean becomes deeper and the land higher (Fig. 5). The crust blocks moved in this maner may contain many thousand cubic miles of matter, and the momentum of such a mass when suddenly stopped is enough to shake the whole earth, and the result is called a tectonic earthquake. The volcanic type of earthquake has the same cause of causes but is more local in character. Being at a shallower depth, its effects are not felt over so great an area and may result from the intrusion of steam accompanying the advance of a dyke or sill into a fault plane which was opened by the elastic pressure of the steam, and the shock may be partly due to the sudden condensation of the steam when in contact with the cold walls.

Such a fault plane opened and closed several times with accompanying noises of rushing steam and heaving of the ground, will explain most earthquakes. The condensed steam escapes as water along with the gases through craterlets, many of which were found at Charleston and New Madrid.

The accumulation of matter of reduced density beneath a mountain range which has been shown to exist by the use of a vibrating pendulum according to the Coast and Geodetic Survey, is to be accounted for in the manner just described. And as the accumulation takes place from the opposite sides of the range of mountains, and the crust blocks are carried in two opposite directions, folding and overthrust occur as a result without the contraction of the planet as a whole, the stretch of normal faults compensating the folding and reversed faults (Figs. 1, 2 and 6). It has been estimated that all the contraction produced by the loss of heat in a hundred million year period would not result in decreasing the circumference of a great circle of the earth more than seven miles. It has also been estimated that if all the folding and overthrust were ironed out of the mountain ranges in a similar great circle, that it would amount to one hundred and twenty to one hundred and fifty miles (Chamberlain). Here is a discrepancy that calls for just the explanation offered; that folding is due to the carrying of the crust against itself from the opposite sides of the axis of accumulation (Fig. 6).

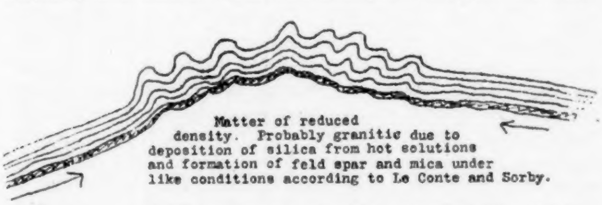



FIG. 6. FOLDING AND ELEVATION OF A MOUNTAIN RANGE BY THE CREEP OF MATTER OF REDUCED DENSITY BENEATH THE COLD CRUST TOWARD THE AXIS OF ELEVATION OR CENTER OF A DOME.

The bottom strata are much more folded and crumpled than the top, because of their higher temperature and greater friction. The crust is carried in two opposite directions, and folding and overthrust in the mountains is compensated for on the sides where the crust is stretched and normal faulted.

Contraction is inadequate to account for the observed folding and if due to folding would be continuous, whereas mountain building is epochal. According to the explanation given, there may not only be *no* contraction, but actual expansion of the earth as a whole. The reason for this is plain. If the earth has a gaseous core *denser* than the solids that will form out of its gases, and its core by loss of heat is gradually becoming solid, then it will occupy more space (Fig. 8), and the earth as a whole will be expanding instead of contracting, which will mean a slowing down of its speed of rotation and a lengthening day. The reason for this is that the momentum of rotation is fixed and if the diameter increases by expansion the speed of rotation must decrease. The question is at once suggested, "Have we any evidence that it is expanding?". And the answer is supplied by the millions of normal faults, all of which indicate a stretching of the crust (Fig. 1), and also by the great rift valley which extends from south of the equator in East Africa to the valley of the Jordan in Palestine.

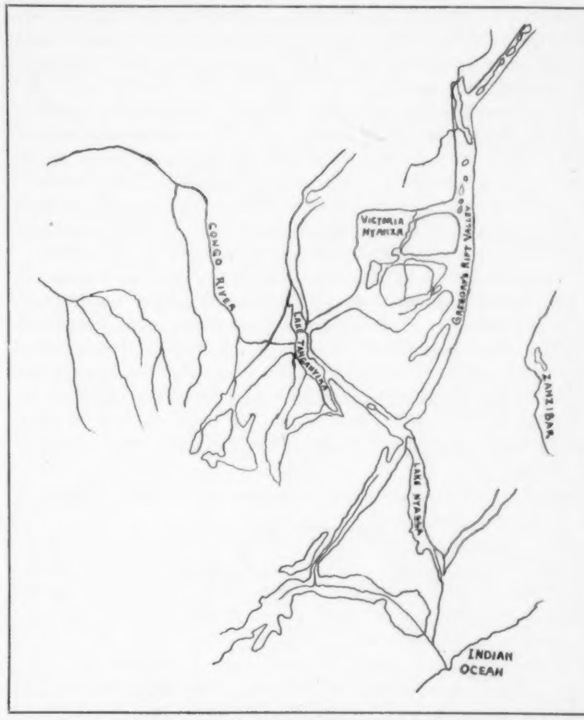



FIG. 7. AREAS OF SUBSIDENCE IN EQUATORIAL AND SOUTHERN AFRICA

By analogy, the so-called Canals of Mars may be the result of the expansion of a once gaseous core on a rigid crust (Fig. 8), with the consequent inflow of most of the water on the surface and the growth of vegetation adjacent to the water. Also the slower revolution of the planet would explain why the inner satellite of Mars revolves in less time than Mars itself does, because the speed of rotation of the satellite would not be influenced by the expansion of the planet.

The point of greatest practical interest to students of this subject is the thought, that if all the land areas are held above the level of the ocean by reduction of density, then we and all air-breathing animals owe our development and existence to that one fact, for without that force all the lithosphere would have remained at a uniform altitude, and the waters of the ocean would cover the entire surface of the planet, and nothing living could develop, except it swam in the limitless sea.

Whether we have elevation or subsidence in a region is a relative matter, and depends on whether accumulation of the leavening gases in the regions below the zone of fracture is more or less rapid than their escape to the surface through volcanic vents, hot springs, etc., or the movement of matter of reduced density from beneath one region to another. The solution of the geyser and hot spring problem is simply a

calculation of the heat units that would have to be derived from the contact of cold surface water with hot rocks. In the Yellowstone Park there are reported to be about 4,000 hot springs, geysers and steam vents. Some of these discharge steadily a large amount of boiling water, while many are relatively small. All told, 20,000 gallons per minute does not appear to cover the quantity, and at 8 pounds per gallon, this would be 160,000 pounds per minute, or 80 tons. Water has a specific heat of 1 and ordinary lava of 0.20, so that it would require the cooling of 5 times the tonnage of lava through the same range of temperature as the water, say 150°, from 62°F. to 212°F., or the same tonnage of lava cooled through five times the range of temperature, or 750° to supply the heat units.

There are 1,440 minutes in a day and 525,600 minutes in a year, which multiplied by 80 tons gives 42,048,000 tons of lava cooled through 750°F. to supply the heat for a single year. At 2.5 tons per cubic yard this represents about 16,800,000 cubic yards, or put another way, a cubic mile of lava would supply heat for 324 years, or 308 cubic miles would be required to supply heat for one hundred thousand years.

The geysers and hot springs are in deeply eroded country, young in a geological sense. Some of the geyser cones show signs of glaciation, so that they are evidently many times one hundred thousand years old. It is impossible that surface waters can come in contact with, or extract the heat from, such a huge quantity of lava by conduction, because the conductivity of lava is so low that if the outer surface be cold, though the interior be hot, relatively no heat would pass to the water.[1]

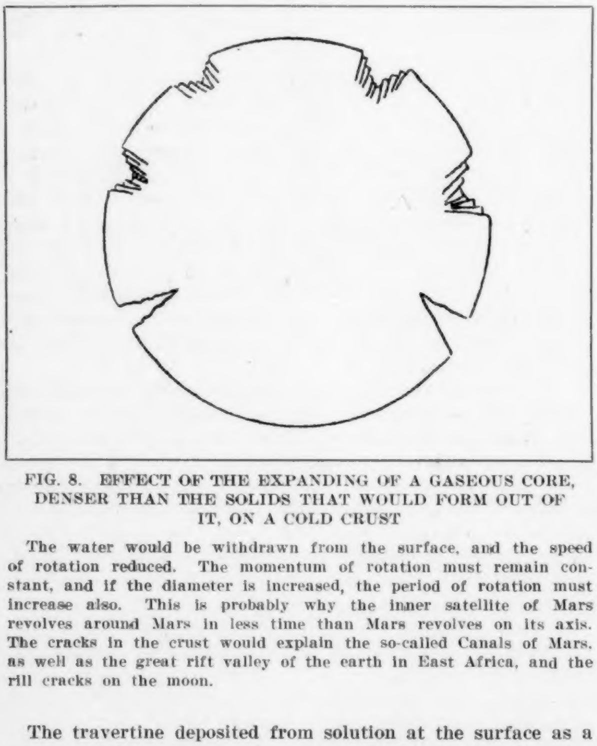


FIG. 8. EFFECT OF THE EXPANDING OF A GASEOUS CORE, DENSER THAN THE SOLIDS THAT WOULD FORM OUT OF IT, ON A COLD CRUST

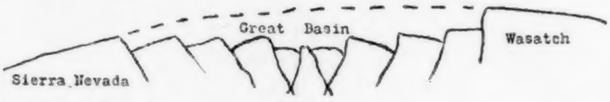
The water would be withdrawn from the surface, and the speed of rotation reduced. The momentum of rotation must remain constant, and if the diameter is increased, the period of rotation must increase also. This is probably why the inner satellite of Mars revolves around Mars in less time than Mars revolves on its axis. The cracks in the crust would explain the so-called Canals of Mars, as well as the great rift valley of the earth in East Africa, and the rill cracks on the moon.

The travertine deposited from solution at the surface as a cone and all the way up the pipe completely isolates the pipe from surface waters as the casing of an oil well does, and therefore condensed steam from the gaseous core forming magmatic water is alone discharged.

The escape of all known gases from volcanic vents and from the fluid lava while cooling has been observed. This is in accord with the known facts of what should be the case according to the law of diffusion of gases applied to a gaseous planet. Hydrocarbon gases have the same reason for being in the gaseous interior as the other gases, and their accumulation and condensation to oil beneath impervious sedimentary deposits would explain the origin of petroleum.

The hydrothermal solutions resulting from the condensation of steam from the interior would leach out the metals from the hot rocks in the path of their ascent, and deposit them in faults and fractures near the surface because of the effect of relief of pressure and falling temperature on the solvent power of the solution, thus making ore deposits.

Finally, the question of probability of the correctness of any hypothesis increases about as the sum of the squares of the number of observed facts that it will explain or agree with. If it will explain all of the known facts which other hypothesis explain and also those which they fail to explain it has an infinitely greater probability of being correct.




After Le Conte.

FIG. 9. THE BLOCK FAULTING IN THE GREAT BASIN IN UTAH AND NEVADA ANOTHER EXAMPLE OF A REGION SHOWING EXPANSION

The foregoing hypothesis explains all[2] known geological phenomena except the rigidity of the earth to tidal distortion and that is assumed to be explained by gravitational compression of the gaseous core which produces rigidity as well as density greater than the solids which may form out of it. Even the hypothesis that the earth is solid is open to the same criticism because the high temperature would destroy the rigidity of a solid core.

## TEMPERATURE AS A MEANS FOR PREDICTING BAROMETRIC CHANGES.

AVIATION is giving increasing importance to weather predictions and aviators must learn not only how to read weather maps but also how to interpret for themselves various local weather indications.

Two French scientists, G. Reboul and L. Dunoyer, have discovered a definite relation between the changes of temperature and those of barometric pressure.

It has been noted that a depression coming from the Atlantic is, in winter, always accompanied with a rise in temperature, while the establishing of a high pressure system is accompanied by a fall of temperature. As variations in temperature usually precede those of the barometer, the former may be used to foretell the latter. Rising temperatures are favorable to a fall of the barometer; falling temperatures favor a rise. This fact may be easily verified by an examination of isobar and isotherm maps. Hence the authors lay down the rules that (1) regions in which the temperature is rising are threatened with a fall of the barometer; and (2) regions in which the temperature is falling are threatened with a rise of the barometer. These rules apply with greater accuracy when the temperature on the land is below that on the ocean. As at present understood, they hold true only for latitudes above 45°, and in the months of winter.

Observations made in the regions of Central Europe during the six months from October to March, 1917-1918, afforded a basis for predictions which were fulfilled in from 64 to 76 per cent, of the cases recorded.—*Comptes Rendus*, July 28, 1919.

[1]For this reason any effort to get power or steam from bore holes or shafts to great depth will end in failure, for after the walls are once cooled the conductivity of the rock is too low to renew the heat readily. This applies to the article by Chas. Parson, F.R.S., in the May number of SCIENTIFIC AMERICAN MONTHLY.

[2]All geological phenomena have their beginning in elevation, erosion and sedimentation, and elevation is shown to be due to reduction of density by magnetic gases and is the first cause leading to all the others which are effects.

# Microbes Two Thousand Years Old

## Methuselahs of the Microscopic World Found in Papyrus of the Ptolomaic Era

Abstract of a Report to the French Academy of Sciences

IT would seem reasonable to suppose that in the more or less elaborate processes by means of which cellulose is transformed into paper in micro-organisms originally existing in the former would be destroyed. But thiss upposedly reasonable theory has just been disproved in the experiments made by the French scientist, M. V. Galippe, a report of which was presented to the French Academy of Sciences on November 3rd, 1919, by M. Yves Delage.

M. Galippe declares that all sorts of paper contains in its fibers living organisms capable of being cultivated. He says:

"I have made use for many years of filter paper sterilized in the auto-clave at a temperature of 120°C. for a period of half an hour. A direct examination of such sterilized filter paper by dilaceration (i.e., tearing asunder) and coloration shows that it contains within its framework and particularly in its fibers a large number of ovoid bacilli united in a mass. Those which we isolated were capable of movement. Several plantings of these were made with positive results.

"According to my observation the presence of living elements in filter paper (even sterilized) offers no great inconvenience, at any rate so far as rapid filtration of liquids is concerned, though it may be so in the case of organic liquids which filter slowly.

"It occurred to me to inquire what influence time might have upon such living creatures contained in paper. My researches extended to papers manufactured in the 18th century and even in the 15th century." M. Galippe continued his experiments as follows: "Fragments of paper were placed in contact with sterilized distilled water frequently stirred. These fragments were afterwards dried and allowed to remain for several hours in sterilized water which was supersaturated with ether. Then after having been dried again these fragments were planted with cultures. The 18th century paper thus treated was examined directly after dilaceration and coloration, and it was found that its fibers contained a certain number of ovoid bacilli. The cultures gave positive results the next day. Microscopic examination showed the presence of numerous rods and of ovoid bacilli and diplobacilli as well as of microzymes and mitochrondial forms. The experimenter next treated paper from a book printed in 1496 in the same manner. In this case the direct examination of dilaceration and coloration revealed large micrococci containing a microzyme bacilli and numerous microzymes. The free micro-organisms in the preparation were capable of movement: those which colorized the fibers of the paper, on the contrary, remained immobile. Positive results were obtained from the sowings on the next day. Besides ovoid bacilli and rods the culture contained extremely curious mitochrondia forms recalling those previously observed by us in muscular tissue as well as in the epidermis of the petals of certain flowers. A number of examinations of the same paper as well as new cultures made with it yielded some results. Furthermore, we found in one of our cultures a bacillus which was morphologic and identical with the tetanus bacillus.

"Encouraged by these first results we were led to inquire whether paper still more ancient would give similar results, and thus through the kindness of a learned gentleman we were able to procure some fragments of Chinese MSS. It was not possible to assign the exact date of this but we were assured that they dated from a period long before the discovery of printing. The first of these two specimens (No. 1) seemed to be older than the second (No. 2) and was more resistant. After having been treated by the method indicated above these fragments of paper were examined with the following results:

"No. 1 contained in the interior of its fibers numerous ovoid bacilli as well as rods, micrococci and diplococci. When sewn upon gelatine these fragments yielded positive results and the culture was found to contain rods, large ovoid bacilli and mitochondrial formations—all of these organisms were capable of movement. Two days after the culture was started we found within the fibers of the paper ovoid bacilli and chains (chainettes) and rods endowed with movement. These micro-organisms exhibited nothing peculiar in the process of their development.

"In specimen No. 2 the direct examination enabled us to perceive in the interior of the fiber ovoid bacilli of considerable volume. The culture made yielded positive results. These cultures contained mitochondria forms already referred to, as well as large rods, a great number of ovoid bacilli and likewise many microzymes. After being incubated for three days, all these elements began to multiply and afterwards passed through a normal development. They were all capable of movement."

These very remarkable results fired M. Galippe's interest to such an extent that he determined to carry the question of the long life of these little Methuselahs still farther. From a well-known Egyptologist, M. Benedite, he succeeded in obtaining fragments of papyrus belonging to the time of the Ptolemies, i.e., about 2,000 years before the Christian era. Upon bits of this papyrus were sown culture mediums. One of them was subjected to direct examination after being torn asunder and colored as usual. The large cells of the epidermis remained united and were found to be unaltered. Some of these cells were empty, whereas others contained micro-organisms of various forms. Among these we distinguished large spherical bodies, rods arranged in chains, ovoid bacilli, micrococci, and diplococci. After three hours of hydration these intra-cellular micro-organisms, which had remained motionless for so many centuries, all began to move. After the lapse of twenty-four hours cultures made with them exhibited signs that they were multiplying and developing—the mitochondria forms as well as the various micro-organisms observed in the direct examination.

These startling and unexpected results of the revival of life in organisms as dead apparently as Pharaoh's mummy induced the investigator to continue his researches, with a slight modification of technique. Fragments of the aforesaid papyrus were macerated in pure ether to free them of the resinous matters contained which had rendered the observations somewhat difficult. When the fragments thus macerated were treated as before they exhibited the same results, except that the intra-cellular micro-organisms were found to be endowed with movement.

Finally the series of experiments was completed by making an anatomical and bacteriological examination of the plant from which the ancient papyrus was made—the *Cyperus Papyrus*. It is interesting to learn that when the epidermis of the stalk of this plant with all its leaf sheaths was examined some organisms were discovered that had been first found in the papyrus of the Ptolemaic era. In the cells of the fibers and in the cultures made therewith, similar mitochrondria forms were found as well as ovoid bacilli, rods, and numerous microzymes, endowed with motion.

Previous researches made by M. Galippe, with the aid of Mme. G. Souffland have likewise established the high degree of resistance to the intra-cellular organisms to the action of heat and to various chemicals. Hence these microscopic living creatures, whose very existence was so long unsuspected, appear to be really entitled to the name of minute Methuselahs.

# Surgical Use of Beef-Bone Screws*

## Their Advantages in the Repair of Fractures and in Bone Transplantation

By M. S. Henderson, M. D.

IN recent years, bone grafting has become established in surgical practice as firmly as the more simple operation of skin grafting, and, as in the latter, it has been found that the autogenous graft is the best. Practically all failures can definitely be attributed to technical errors, such as too small a graft, infection, inadequate fixed bony approximation of the graft to fragments, and poor postoperative fixation of the part. I have found beef-bone screws to be a great aid in attaining this fixed approximation of the graft to the bone, and I believe that they would be employed more if their uses and methods of preparation were more generally known. I am well aware of the fact that a few surgeons have used them, but I present this article on their preparation and use believing that it may be of interest to others.

There can be no doubt that, from a purely theoretical point of view, screws made from the bone of the patient, such as the bone pegs advocated by Albee, would be better than beef-bone screws. The theory when put into practice, however, has so many objections, such as the difficulty of making the screws or pegs properly, and the extra amount of bone used, that I have come to the conclusion that the beef-bone screws are to be preferred. The question of whether the beef bone is suitable for a graft does not enter into this discussion, for all that is demanded of the screws is that they provide fixation of the autogenous graft to the fragments. They are usually absorbed completely within from six months to a year.

We know that the bone transplant must be held firmly in position and have broad contact with the bone to which it is to be grafted. While in theory an inlay graft is best and occasionally it is possible to obtain a perfectly fitting inlay by the use of double bladed circular saws, in actual practice this

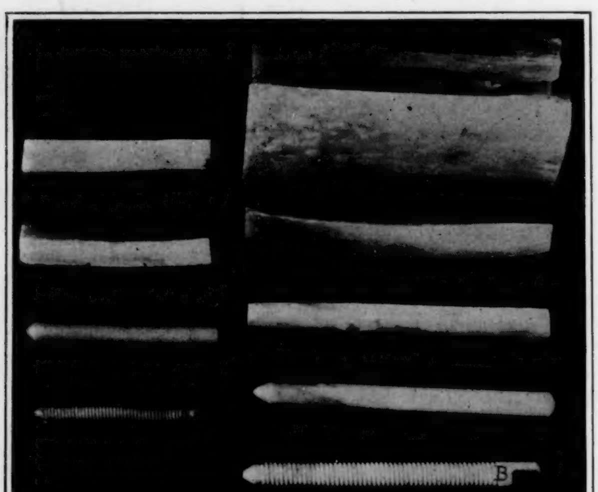



FIG. 1. PIECE OF BEEF-BONE WITH STRIPS, BLANKS AND SCREWS: *A*, MEDIUM SIZED SCREW, 10 BY 24; *B*, LARGE SIZED SCREW, 5/16 BY 18

is not easy. If the blades of the twin saw are out of line there will be a considerable discrepancy in the size of the graft and the slot. It is necessary to employ some means of securing the graft to prevent it from moving. Kangaroo tendon or catgut sutures thrown about the fragments and the graft are not satisfactory. Beef-bone screws properly placed are well-nigh ideal for the purpose.

PREPARATION OF SCREWS.

Fresh beef bone is obtained usually from the tibia, the joint ends are sawed off, and the shaft is boiled for one and one-half hours to remove the tissue and the marrow. The shaft is sawed into pieces 3¾, 2⅜ and 1¼ inches long for the large, medium and small size of screws, respectively. The medium sized screw is of aid in many situations, and many more of

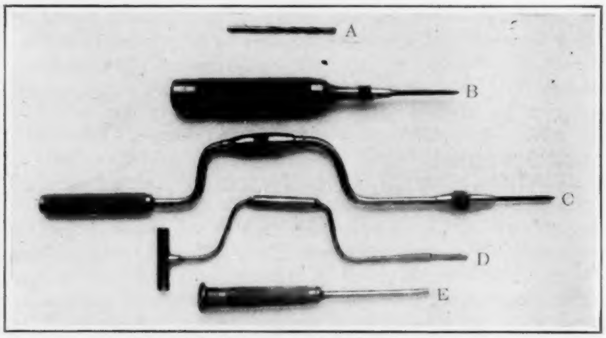



FIG. 2. INSTRUMENTS NECESSARY FOR THE PLACING OF BEEF-BONE SCREWS: *A*, NO. 17 TWIST DRILL; *B*, STRAIGHT HANDLED 10 BY 24 TAP; *C*, OFFSET HANDLE 10 BY 24 TAP; *D*, OFFSET HANDLE WRENCH WITH HEXAGONAL HEADED BEEF-BONE SCREW IN SOCKET; *E*, STRAIGHT HANDLE WRENCH

these are used than of either the large or the small screws. The sizes used by us are standards, and in mechanical terms the large screws are known as 5/16 by 18, the medium size as 10 by 24, and the small as 6 by 32. The lengths adopted are arbitrary and may be varied to suit the needs of the case. The pieces are sawed lengthwise into strips; their width varies according to the diameter of the screw to be made. The strips are roughly sized in the vise by filing, and are then turned to the proper size, pointed, and the head rounded in the lathe. These finished blanks are placed, for one-half hour, in petrolatum brought to the melting point in a double boiler, in order to replace to some extent the natural oils removed by the boiling. This renders the bone a little less brittle and less likely to crumble when being threaded. The heat must not be extreme or the bone will be overheated and rendered almost chalky.

The blanks are placed in the lathe and threaded by using a standard machine screw die. Petrolatum is freely used on the die while the threads are being cut. The large blank is threaded with a standard 5/16 inch by 18 die. The head is 5/16 inch long and is flattened on two sides to ¼ inch in thickness to fit a special wrench. The large screw when finished is ordinarily 3½ inches long, but this may be varied. The medium sized blank is finished into a screw 19/100 inch in diameter and 2¼ inches in length (Fig. 1). A little more care is necessary in putting the threads on this size than on the large screw, and we have found it necessary to step down the threads by using three dies: 12 by 24, 11 by 24, and 10 by 24. The small blank is for a screw 14/100 inch in diameter and 1⅛ inches long. It is necessary to step down the threads for this screw as follows: 8 by 32, 7 by 32, to 6 by 32. The heads of the two smaller screws are ¼ inch long and ¼ inch in diameter to allow for hexagonal shaping to a 3/16 inch standard. These fit a specially made socket wrench fitted to

the end of a small brace. When the screws are received from the machine shop they are thoroughly scrubbed with soap and water and boiled in water for thirty minutes. They are then kept in the instrument case and boiled as required, just as any instrument is boiled. The screws are cheap, easily made and well tolerated by bone. The one objection to them is that they are brittle and will not withstand any great amount of stress, particularly if there is any torsion with the strain. For his interest and skill in the actual manufacture of the screws we are indebted to Mr. George Little, chief of the instrument shop of the Mayo Clinic.

### SURGICAL USES.

Even though the beef-bone screws are well made, they cannot be used successfully unless there are at hand the proper instruments for placing them. Above all, it must be remembered that they withstand very little twisting force, and if they bind when being screwed in, they will break. For the

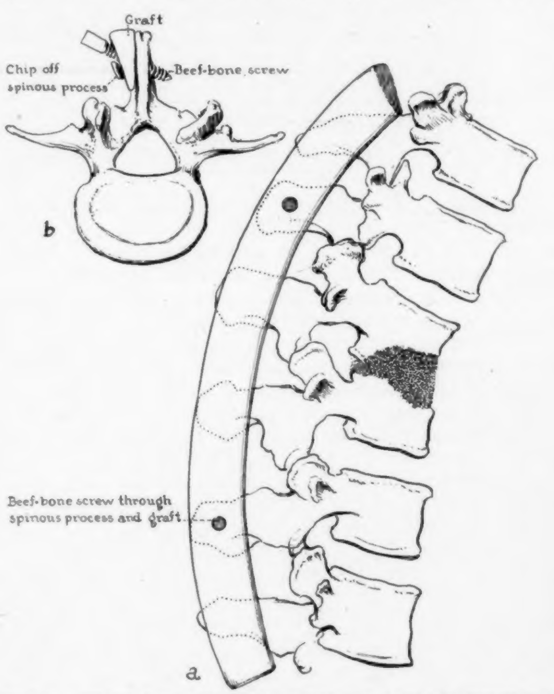



FIG. 3. CURVED TIBIAL BONE GRAFT (*a*) HELD SECURELY IN PLACE BY THE AID OF TWO BEEF-BONE SCREWS PLACED THROUGH THE GRAFT AND SPINOUS PROCESSES; *b*, TRANSVERSE SECTION SHOWING THE RELATIVE POSITIONS OF THE GRAFT, SPINOUS PROCESS AND BEEF-BONE SCREW

large size, 5/16 by 18, a special socket wrench is used. I have used the large screws only in situations such as the head of the femur or the condyle of the femur. If not passed through any cortical bone, they are of sufficient strength to make their own threads in the soft bone, and the drill hole bored by a 9/32 inch twist drill does not need to be tapped. Since the medium sized screws, 10 by 24, and the small screws, 6 by 32, have a hexagonal head of the same size, the same wrench fits the two (Fig. 2, *D* and *E*). For the medium sized screw the holes in the graft and fragment are bored by a No. 17 twist drill (Fig. 2 *A*) and the hole is tapped by a 10/24 tap (Fig. 2, *B* and *C*). For the small screw the hole is bored by a No 29 twist drill and the hole tapped by a 6/32 tap. The drills can be used on the electric motor or on the hand drill. The tapping must be carefully done by hand. Handles of different styles for the wrench and taps will be found convenient for the different situation (Fig. 2, *B* and *C*). If the subcutaneous structures are scanty, the heads of the bone screws may be removed either by bone-biting forceps or a Gigli saw.

In recent spiral or oblique fractures of the long bones, recent fractures of the neck of the femur, of the olecranon process, and in certain fractures of the patella, the screws are an excellent means of obtaining coaptation of the fragments. They are a splendid means of fastening the bone graft to the spinous processes, as is necessary in the operation advanced

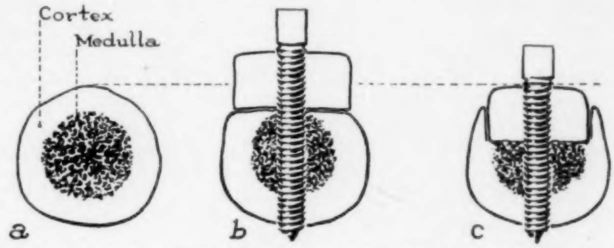



FIG. 4. *a*, TRANSVERSE SECTION OF BONE; *b*, LARGE BONE GRAFT IN APPOSITION TO FRAGMENT FROM WHICH PART OF CORTEX HAS BEEN LIFTED TO PERMIT BROAD CONTACT; GRAFT HELD IN PLACE BY BEEF-BONE SCREWS THROUGH THE OPPOSITE CORTEX; *c*, INLAY GRAFT; BEEF-BONE SCREW PLACED THROUGH GRAFT AND THE OPPOSITE CORTEX

by Albee for tuberculosis of the spine, and are the only means known to me whereby proper bony approximation can be assured (Fig. 3). They are not so ideal in delayed union or for ununited fractures. It has been my experience that in fractures of these two groups, it is best to accept no compromise but to employ a large graft so that when the operation is completed there is from 20 to 25 per cent more bone in the

FIG. 5. AT LEFT, ROENTGENOGRAM OF UNITED FRACTURE OF LOWER THIRD OF TIBIA AND FIBULA OF EIGHT YEARS' STANDING IN A WOMAN, AGED 20. AT RIGHT, FIXATION OF SAME FRACTURE BY MEANS OF FOUR BEEF-BONE SCREWS, AND PIECE OF ENTIRE THICKNESS OF FIBULA FROM UPPER FRAGMENT, PLACED AGAINST FRAGMENTS OF TIBA

fractured region than is normal (Fig. 4). When we are dealing with a case of long standing nonunion of the humerus or of the bones of the forearm, the bones are often osteoporotic and smaller than normal. In such cases every surgeon of experience has seen his inlay or intramedullary grafts thin out and finally break at the line of fracture. The absorption of the graft takes place so rapidly, or perhaps it would be better

to say that the deposition of new bone is carried on so slowly, that the graft is partially absorbed and cracks on slight stress, and a technically well performed operation in a properly selected case is discredited. In such a predicament the surgeon should not be dismayed and give up all hope of obtaining union, but he should at once see that the part is thoroughly immobilized for at least two months more. In the majority of cases, and particularly if the transplant has been of good size, union will occur. I believe that the excess of bone elements brought to the devitalized area is an important causative factor in bringing about union, and this is my reason for so strongly emphasizing the large graft. If the roentgen ray discloses very marked osteoporosis of the fragments, exercises should be instituted prior to operation, regardless of the fracture, because it is only by this means that the osteoporosis will be overcome. Many failures to obtain bony union are due to operating on bones that are far below par in bone salts and bone forming elements. Obviously, the simplest way to prevent a fracture of the transplant is to place a very large graft, and by this I mean large in diameter as well as in length (Fig. 4, *b*). The discredit of the bone graft found in some of the recent writings, particularly from abroad, is more than likely due to the author's experiences with fracturing of the grafts, the cause of which is probably the use of too small transplants.

The technic of the inlay graft will not permit the placing of a very broad piece in the fragments (Fig. 4, *c*). On account of failure and accidents with the ordinary intramedullary and inlay grafts, and the belief that it is most important to place more bone in the fractured area than is normally there, it has been my custom for some time to proceed as follows: The bone ends are carefully freshened so that as broad an area of their surface as possible will be in firm contact. The medullary cavity in each fragment should be opened. From one-fifth to one-fourth of the entire thickness of the bone from each fragment on one side is removed for a goodly distance above and below the fracture. This should not remove the entire cortical wall. The graft, which is a piece of healthy bone from the tibia or the entire thickness of the fibula, flattened on one side, is greater in thickness than the amount of bone removed from the fragments, and is placed against their freshened surfaces, the ends of which are in firm apposition and the medullary cavities in line. It is held in place by two or more beef-bone screws through the graft and through the remains of the proximal cortex and the opposite cortex of each fragment (Fig. 5).

SUMMARY.

1. Beef-bone screws are a great aid in securing firm fixation of the bone graft to the fragments in fractures, and of the graft to the spinous processes in the operation for fixation of the spine.
2. They are well tolerated by the bone and are gradually but completely absorbed.
3. Bone screws have not the strength of metal and must not be expected to stand great stress. Careful provision must be made for postoperative fixation of the extremity.
4. Drills, taps and wrenches of the proper size are essential for the placing of beef-bone screws.
5. The bone graft as commonly used in the intramedullary and inlay methods is too small. Fracture of the graft rarely, if ever, occurs if the graft is large enough so that when the operation is completed there is from 20 to 25 per cent more bone in the fracture area than there is normally.

## LEMONS AND VITAMINES.

IT has long been known that the juice of lemons and oranges and of the citrus family in general form an excellent remedy for scurvy, that much dreaded disease which was a former scourge of sailors upon long voyages. Recent experiments made by Mr. A. Harden and Mr. S. Zilva have shown that the curative action is not due to the citric acid of the lemon but to the vitamines contained in the fruit. These investigators eliminated from lemon juice the citric acid and the other organic acids it contains and found that the residue still contained the major portion of the anti-scorbutic substance. Their methods were described in the *Bulletin of the Agricultural Institute of Rome* for December, 1919.

The lemon juice was first treated with calcium carbonate and then with alcohol and the filtered liquid, to which was added 1 gram of citric acid per liter, was then evaporated to dryness in a vacuum at a temperature below 40°C. The dry residue obtained was found to be a very active remedy for scurvy when taken into the alimentary canal. It proved inactive in the form of subcutaneous injections even in large doses. When swallowed it possesses great *curative* power but no *preventive* power. The investigators succeeded in curing a monkey suffering from an advanced stage of scurvy by the aforesaid dry residue of lemon juice.

It is evident that such a preparation might be of great value to travelers by sea or land liable to be unprovided for long spaces of time with the fresh fruits and vegetables from which most of us obtain the necessary supply of vitamines.

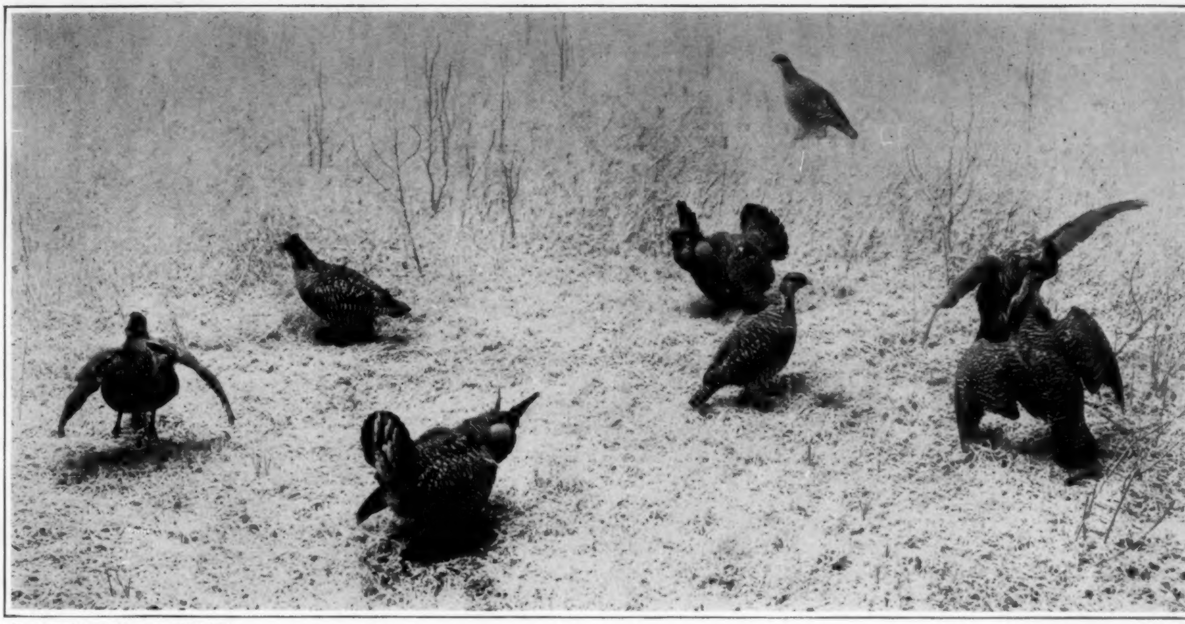
## INCREASING LEAF GROWTH BY PERFORATING THE ROOT.

PROF. MARIO CALVINO, the director of the Agronomic Station of Santiago de la Vegas, in Cuba, has recently devised a novel device to be applied in intensive horticulture. This consists in making a horizontal perforation in the primary root in order to obtain a more luxurious development of the foliage in those plants which are cultivated for the sake of their leaves, cabbage, lettuce, parsley, chicory, etc. Experiments on parsley caused the plants thus treated to attain a diameter of 80 cm. and a height of 40 cm., while the control plants had a diameter of only 55 cm., with a height of 30 cm.

Prof. Calvino has also made some interesting experiments in the direction of increasing the yield of plants by certain injections. The Russian botanists were the first to study such effects, but it was Prof. Petit of Paris who first applied the method in agriculture. When Prof. Calvino held the position of Director of the Central Agronomic Station of Mexico, he undertook in 1912 a series of experiments to determine the practical value of such injections. An old pear tree which blossomed freely every year but never bore fruit was subjected to the following treatment: at a short distance above the ground the trunk of the tree was perforated as far as the zone of the fiber-vascular bundles, and a small glass tube was inserted in the hole; this tube communicated by means of a rubber tube with the bottom of a receptacle placed at 1.5 m. above the ground and containing a nutritious solution consisting of 18 liters of water plus 19 gr. of iron sulphate plus 10 gr. of sodium nitrite. The tree completely absorbed the solution in about three days' time. The following month its leaves were found to be larger and more glossy than those of the control trees (two other old pear trees, which likewise blossomed abundantly but bore no fruit) and it proceeded to bear a considerable amount of fruit.

In 1913, Prof. Calvino experimented with another sterile pear tree but with the following solution: 20 liters of water plus 5 gr. of super-phosphate plus 5 gr. of sulphate of phosphate plus 5 gr. of sodium nitrate plus 5 gr. of sulphate of iron. The pear tree absorbed more than 50 liters just before it flowered; it blossomed vigorously and bore fruit.

This method of treating plants opens wide vistas. Thus it may be possible to inject in the plants the attenuated virus of bacterial organisms or to inject vegetable products such as camphor, etc., in order to produce more vigorous vegetation or, finally, to inject a solution of the substance yielded by the plant. Thus sugar might be injected into the sugar cane in order to create "the habit of the substance," thus obtaining more productive varieties.



Courtesy of Amer. Museum of Nat. Hist.
THE LOVE MAKING OF THE PRAIRIE HEN—A GROUP IN THE AMERICAN MUSEUM OF NATURAL HISTORY

# Dancing Birds

## The Art of Courtship and the Play Impulse

### By Dr. Kurt Floericke

LIKE the art of song that of the dance is employed by many birds primarily in the courtship of the female—perhaps indeed the latter art is even more useful as an aid in the conservation of the race, and it is found employed as a means of courtship and of the showing off of the male before the female in all kinds of birds. Secondly the dance, like the song, constitutes a challenge to a rival for the fighting of a duel, and on this account frequently ends with a more or less serious combat. Just as many birds, however, continue to sing not only in the mating time but more or less as an expression of well being, there are many birds who exercise the art of the dance at all times of the year merely to give expression to exuberance of mood, and, strangely enough it is often the most serious and dignified birds who are thus seized by the demon of the dance. Thus the crane, the king of the swamp birds, who is usually so stately and dignified is at times seized by a whim of the most extravagant abandon. When this happens the long legged fellows hop about, assuming the drollest positions whirling about their own axis and, in short, executing a regular dance, which excites irrepressible laughter in the beholders. In their enthusiasm the big birds take up stones or bits of wood from the ground and sling them over their shoulders, then seize them again in their beaks; they raise their wings and altogether behave as though they were mad, yet without sacrificing any of the grace and beauty which belongs to them.

The biggest bird of all—the ostrich—is a most indefatigable dancer, particularly enjoying the waltz—and a quick waltz at that! The huge camel necked bird whirls about with such mad rapidity that the spectator actually feels dizzy. In fact the birds themselves occasionally become so dizzy that they fall to the ground, sometimes breaking a foot.

The moor cock is another dancing bird from which the peasants of upper Bavaria have borrowed their famous "flat shoe dance" (clog dance). When this brilliant black bird with his red rimmed eyes and his beautiful lyre-shaped tail comes forth in early dawn upon the dewy meadows to woo his mate he first utters curious harsh cries and then a sort of muffled gobbling sound which increases in rapidity, until it becomes a wild hurly-burly in the midst of which certain crowing tones can be heard now and then. At the same time the tail is spread into a fan while the wings are raised and held away from the body, while the head and neck, with ruffled feathers, are stretched forward; then the cock jumps hither and thither, turns himself about in circles and presses his head so close to the earth that in course of time he actually rubs away the so-called "chin feathers." Madder and madder grows the ecstasy of this wondrous bird, wilder and wilder are his motions, until one might think he was fairly crazy. If a second cock happens to cross his path at such a moment a heated duel ensues, which is, however, harmless in spite of the fury of the combatants. Many other gallinaceous birds behave in a similar manner. The gold pheasant, for example, is an elegant exponent of the art of dancing the minuet. He trips back and forth before his would-be mate in the most graceful positions . . . inflating his gorgeous neck and seeking by means of graceful turns and twists to display his beauty to the best advantage before his chosen one. Sad to say when his wooing succeeds he turns out to be an exceedingly brutal husband, as has been known to occur in the case of human beings!

"The mirror peacock" of Borneo, whose back and wings are adorned with brilliant green feathers edged with bright violet, not only dances but constructs regular dancing floors so to say, since he selects in the midst of the forest at some very lonely place a suitable spot of ground and entirely clears it of all vegetation for a space of about one square meter so that it resembles a newly made tennis court; in the middle is a small elevation upon which the cock stands to dance and display his gorgeous plumage. Among these birds

*Translated for the *Scientific American Monthly* from *Kosmos* (Stuttgart), January, 1920.

the fighting between rivals is very violent and often ends with the death of one of the combatants, since these birds are armed with two strong sharp spurs upon each foot.

The argus pheasant found in Sumatra behaves in the same way. This bird is familiar to nature lovers through the extended description made of him by Darwin. . . . This bird is distinguished from all other kinds of birds by the fact that the fore pinions are very short whereas the brachial pinions are extraordinarily elongated being at the same time broadened toward the end and weak of shaft. These remarkable feathers, whose ground coloring is a beautiful mahogany brown, are decorated with large iridescent eye spots with a light border surrounded by a darker tone; this peculiar effect of light and shade gives a really surprising impression of a three dimensional plastic curving or arching. This stately bird is extremely shy of men and lives in the deepest solitude of the forests. Here each male bird builds his dancing floor, which he takes the greatest pains to keep neat and of which he appears to be very proud. Such a dancing floor has an area of from six to eight square meters and the bird carefully removes any bit of dirt and every dead leaf which may chance to fall upon it. Except when seeking food the argus pheasant remains constantly upon this dancing place, which, therefore, constitutes his dwelling, in a certain measure. So far as I know the dance itself has never been seen by human eyes, since these birds, whose far resounding cry lures the hunter to seek him, always slips silently away just in time to avoid the coming of the human being whose presence he has detected through his keen senses.

The strutting and tripping dance of the domestic turkey and peacock are familiar enough, but the wild progenitors of both these birds found in Mexico, North America and in the Sunday Islands and in the East Indies execute a beautiful dance in which the tail is spread wide, to display its full beauty. . . . It must be a wondrous sight indeed to observe a scene in wild nature when a dozen or more peacocks spread their gorgeous tails and execute their dance steps. At the slightest disturbance the tails are instantly folded and the birds shoot like gleaming arrows through the sun-bright air. During his courtship and the continuing dance the turkey utters his well-known gobbling sound, at the same time scraping his wings upon the ground and strutting about the turkey hen until he has won her favor.

The plover is a very elegant dancer. It begins by hovering about the desired mate on the wing, at the same time performing the most incredible twists and turns, throwing itself from one side to the other and actually turning somersaults in the air, so that the spectator sees first the dark green feathers of the back and then the white belly of the bird. Finally it rushes down to the ground but does not immediately approach its mate, but stands off from her at a little distance and greets her with rapid bowing motions in quick succession; then follows the actual dance during which his lady love cheers him on by uttering a peculiarly disagreeable screech; then the male, still continuing his dance, seizes a bit of grass or straw and throws it behind him with a graceful gesture as if delicately signifying that it is time to begin the building of the nest. The excitement shown by the male is finally imparted to the female until she too begins to respond by uttering cries and taking dancing steps until the pretty play comes to an end.

FIG. 1. THE OSTRICH IN ITS DROLL WOOING POSTURE

In Central Asia I also saw the "stilt-runner," an elegant little snipe with incredibly long red stork legs, executing its hopping dance with horizontally outspread wings; because of the long legs of this bird the dance looks very comical and awkward. While our common snipe (*scolopax gallinago*) carries out its courtship entirely in the air, making meanwhile the well-known goat-like bleats which characterize it, its near relative, the *Gallinago media*, does its wooing upon the ground. (Fig. 2.)

In the evening twilight 8 or 10 of the males or even more gather regularly upon the same spot in a marsh meadow which can be recognized as their dancing floor by the downtrodden grass. The females stand around as spectators while the males dance back and forth before them with their plumage ruffed up while they alternately spread and close their tails like a lady's fan, at the same time uttering soft and tender notes interrupted by violent snapping of their bills, and showing by their whole demeanor that they are in a condition of rapturous exaltation.

The stately curlew I have also learned to recognize as a dancer and dancing the galop at that! This bird runs rapidly forward in a straight line with head and neck pressed close to the earth while uttering an almost unbroken succession of its magnificent flute-like trills.

Social dances are executed by the splendidly plumaged Tanager (*Tanagridae*) birds in the primeval forests of South America. Almost each kind has its own peculiar dance. One of these reminds one strongly of the well known children's game "puss in the corner." A number of birds take their places at definite spots while one of them stands in the middle and sings. When a certain note is heard in his song all the birds instantly change places, trying to secure another location.

FIG. 2. SNIPES AT COURTSHIP


FIG. 3. DANCING CRANES

FIG. 4. BUILDING A DANCE BOWER

The one left out proceeds to the center and begins to sing the same song.

### THE PLAY IMPULSE.

This example is evidently an instance in which the dance becomes an expression of the delight in play, which is an extremely strong instinct in birds, on which account the owners of caged birds should take care always to give their pets some opportunity to exercise their playful activities. One need only observe a troop of sparrows who have found a smooth slide somewhere to see how they make merry with it.

Likewise in the primeval forests of South America but exclusively in well watered rocky valleys of the mountain side lives the marvelous helmet crowned and scarlet clad cliff bird. As we know from Schomburgk's classic representations this bird makes use of flat rocks as dancing floors. Upon such a place great numbers gather while one of the males executes a solo dance during which it makes all sorts of playful motions, scratching the hard rock with its feet and spreading its tail into a fan. When it becomes tired it utters a definite cry never heard at other times and makes way for a new dancer to entertain the crowd; the females meanwhile receive the retiring performer with loud cries of applause.

Our lapwing handles his fan in a masterly manner while dancing. His fan is not his tail but the beautiful crown of feathers which adorns his head and which he knows how to close and half close with the greatest grace while wooing his mate with tripping dance steps.

A very graceful dancer, too, is the mourning stonechat which I have often observed with the greatest delight in the wildest mountain regions of Spain, where this bird, whose plumage is intensely black but relieved by the dazzling white of his vary-colored tail feathers, lends more vivacity than any other creature to the melancholy sunburnt landscape. He dances trippingly about upon the cliffs, constantly changing his position, however, and one never grows tired of watching his nimble and graceful movements.

Most kinds, too, of the "love birds," those gay little tropical birds which were so popular among our bird lovers before the war, and were successfully bred by some of them, must be counted among the dancers. Many of them have the same habit as that of the plover of seizing a bit of grass or straw in the beak while dancing and many of them, too, perform a series of rapid and energetic bowing motions. Among most of them the dance consists merely in an incessant hopping up and down upon the same spot, accompanied by a monotonous and unattractive sing-song sound.

Among the marvelous paradise birds of New Guinea the special object of the dance is to display the fabulous beauty of the male. The bird places itself upon the dry top of an old tree—often many of them at the same time—and utters peculiar quacking sounds, while at the same time opening and shutting the splendidly colored tufts of feathers at his sides and erecting the long and waving ornamental feathers until they look like a comb. It is a magnificent sight and the bird always endeavors in the most vigorous dancing to preserve from injury the delicate plumes which adorn him. A very remarkable biological observation in regard to this has been recently made to the effect that since the males are shot in such large numbers because of their valuable plumes there has come to be an excess of females, in consequence of which, in a great many cases, the female takes the active part in the courtship instead of the male. To be sure the female paradise bird is a most uncomely and unattractive creature and so her dance is lacking in that intriguing charm which surrounds the male clad in his glorious plumage.

Among the relatives of the paradise bird are the bower birds found in Australia and New Guinea, which are remarkable in that they erect real dance bowers of leaves and seem to attach great importance to the decoration of these places. The silk bower bird, for example, builds upon the ground in some lonely spot in the wood a roof-like bower out of twigs, etc., which has an open entrance on each side (as shown in Fig. 4).

The walls of this structure are decorated with all sorts of gay ornaments, such as parrot feathers, red berries, green moss, bright flowers, etc., which are always replaced by fresh ones when the original ones have withered, while the old material collects in a rubbish pile behind the bower. At the front door of the bower a special decoration is placed composed of bright colored mussel shells, bones bleached white, prettily colored stones and pebbles and glittering and unusual articles of all sorts, often in really astonishing quantities. Likewise in the still more artistic bower more than a meter long built by the Kragenvogel there is not infrequently found half a bushel of bones and mussel shells. In their choice of these decorations the birds are very fastidious and it has been discovered from an examination of the shells found that they are sometimes brought from a distance of a mile or more. The bower birds, like the bird of paradise, belong to the group of the ravens, and have well marked thievish instincts like our own ravens. The "gardener bird" builds itself a circular bower with a spherical supporting column made of moss while the walls are made of orchid stems. In front of the bower the bird clears a special dancing floor and executes his courting dance inside and outside of the bower until a female is induced to enter.

Among our domestic song birds there are also a few zealous and admirable dancers. I remember with especial pleasure, for example, a blue-throated warbler which I kept for a long time in a cage. During the mating season this bird danced with its head bent far backward so that the inflated blue neck was beautifully displayed; the tail was spread into a fan and the wings were held downward while the performer turned round and about in the rhythm of a waltz. The most curious and remarkable thing about this bird was that it quite obviously took great pleasure in having me share its dance, so that when I wished to incite it to dance I had only to do a bit of dancing myself in front of its cage. This graceful exercise was usually ended by the gift of a special dainty in the form of a nice fat meal worm to my dancing partner.

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## THE COURTING ANTICS OF THE FLY.

An entertaining account is given by a German naturalist, named Erwin Lindner, of the curious "dance" made by a fly (*Chloria demandata Fabr.*) which he happened to see on a sunny garden bench in Semendria. The time was five o'clock in the afternoon, November 1st, 1917. The female fly was resting upon the bench occupied apparently solely with making her toilet. The male fly, on the contrary, was obviously in a state of great excitement, executing a mad sort of dance in front of his would-be mate. Now he would stand off at a little distance from his lady love with his head turned toward her, and now he would encircle her several times, dancing about her at a distance of a few centimeters. Usually, however, not completing the circle—but before finishing it—running in the direction of a chord of the circle toward her head, stopping short then, for an instant, and making some remarkable sidewise movements. Finally, he raised the left front leg and rapidly stroked the head of the female with it. Then he made another circle about her head, repeating this a great many times with increasing rapidity. The female remained motionless most of the time but suddenly rushed at the male seizing the end of his body with her forelegs, apparently striving to hold the male fast while he struggled to get away but without moving his wings. Then the two separated, the female went back to her old place and the male began his waltz about her once more. First he danced about her, then swiftly turned about, ran toward her, raised his left wing so that its point almost touched her and waved it rapidly. The female ran away repeatedly followed by the male, but always came back to her former place, until the courtship was finished.

# Producing Flies with Horns*

## Remarkable Experiment in the Artificial Modelling of the Chitin

**By René Merle**

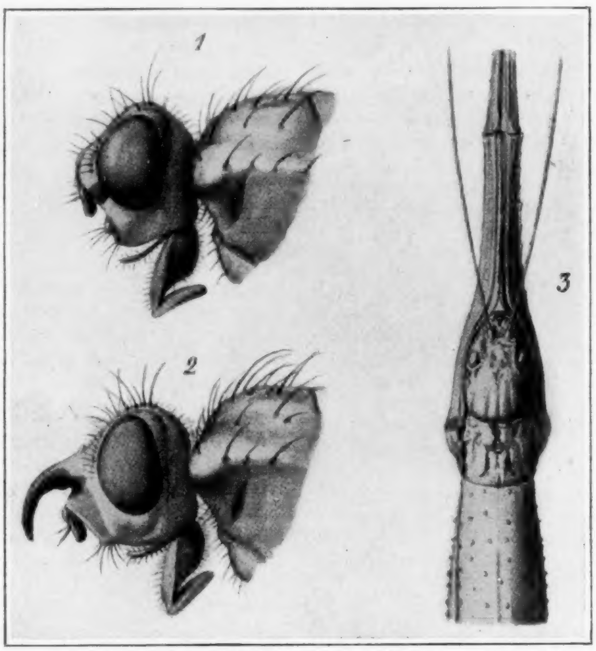
AT a meeting of the Academy of Sciences which took place upon the 10th of last November, Professor Cuénot of the Faculty of Sciences of Strasbourg presented a very interesting note upon the reciprocal adaptation of the forelegs and the head among the Phasmids.

It is a matter of common observation that in a large number of these insects the upper portion of the forelegs is hollowed out on the side next the head. During the daytime while the insect is at rest the forelegs are extended towards the front and clasp each other in the line of the body, thus forming between them a narrow, rigid sort of trough in which the closed antennae rest. In this position the aforesaid curve of the thighs (femurs) exactly fit the outline of the head beneath the eyes, which remain uncovered. The two other pairs of legs do not have this shape. This peculiar formation is found not only in the Phyllida, but in the Bacillae and the *Carausius*. In all of these the adult insect frequently extends its forelegs with the head hidden between them, thus looking like a bit of stem; it has been supposed that this attitude helps to conceal the insect from the eyes of its enemies, and consequently to protect the species; this, in fact, is one of the most commonly cited instances of protective mimicry.

There has been a good deal of debate with regard to the mechanism of this neatly fitting curve in the forelegs for the reception of the head and antennae, a peculiar form which exists from the very moment of birth, when the young creature issues from the shell.

Professor Cuénot points out that even if the clasping of the forelegs is a detail which is of some utility with regard to defense, it is nevertheless quite evident that this utility could not have existed until the shape of the legs had attained its present state of perfection, whereas it is impossible to conceive of a process of slow variations during which the law of selection would favor those individuals whose legs, by reason of some chance variation found it possible to approach each other near the median line. This, in fact, is the very argument raised by objectors to Darwin's theory of the constructive role played by natural selection, an objection based upon the idea of those organs which are of no use until they have arrived at a perfect state. It is obvious that the early stages must have been entirely without utility, and, consequently, could have played no part in determining natural selection.

"Neither is it possible to believe in some chance mutation which happened to produce the mutually adapted arrangement of the legs and head, followed by a selection favoring the mutants as being better protected than the non-modified Phasmids.




ARTIFICIAL AND NATURAL MOLDING OF THE CHITIN

1. Normal head of the *Fucellia caritana*. 2. Head after artificial formation of horn. 3. Curved forelegs fitting around the head of a phasmid.

"For their part, the Lamarckists would say that the Phasmids, experiencing the need of clasping their legs together in front of them, made such strenuous efforts to accomplish this that the comparatively plastic anterior femurs became curved by pressing against the head, and that after a certain number of generations this curvature became fixed in the ontogenesis, so thoroughly as to appear in the embryo at the present time without any connection with the mechanical cause which occasioned its development in the Phasmids after hatching."

As a matter of fact, neither of these interpretations is satisfactory and as it happens the real cause of this phenomenon is far more simple. This curvature of the legs does not exist in the embryo: it makes its appearance only after the individual has been hatched from the shell and is occasioned by a very simple mechanism closely studied by M. Cuénot in the *Carausius morosus*. At the moment when the insect escapes from the shell its body curves upwards and the top of this curve makes its exit first, the head, antennæ, the legs, and the end of the abdomen remaining still within the shell. The region of the head then disengages itself, but remains wedged between the thighs of the forelegs. At this moment the chitin of the legs is still soft, whereas that of the head is already considerably harder. Consequently the head makes an impression upon the chitin of the legs and these become molded to fit it. When the insect has completely emerged the chitin becomes tough and resistant everywhere, but by that time it has already acquired the remarkable form which has caused the shedding of so much ink. It is evident, therefore, that the perfect adaptation which exists between the shape of the legs and the head and antennæ which they surround has no decisive significance; it is merely a molding of the chitin which takes place during the act of hatching.

As a result of these observations Professor Cuénot holds that "this phenomenon is due to a fortuitous mechanical accident, entirely independent of any question of utility or of custom; the animal takes advantage of this accident to assume during the daytime a special attitude which happens to be convenient for repose, or advantageous from the point of view of camouflage; but it must be remembered that it is the mutually adapted arrangement of the head and legs which determines the attitude and not the attitude which occasions the arrangement."

This peculiar plasticity of the chitin at the instant when the metamorphosis takes place has attracted too little attention heretofore. It is, however, a very remarkable circumstance, for Professor Mercier of the Faculty of Sciences of Caen has been able to make use of it to produce actual monsters, horned flies, as related by him in the *Comptes*

*Translated for the *Scientific American Monthly* from *La Nature* (Paris).

*Rendus* of the French Society of Biology, November 29, 1919.

He happened to find in the littoral zone at Lac-sur-Mer certain Diptera, the *Fucellia caritana*, among which one individual had a small horn between its eyes. In order to find out what could have produced this malformation he attempted to reproduce it experimentally. For this purpose he placed pupae of this insect in small glass tubes of such a diameter that an adult fly could not turn around in them, the tubes being closed at each end by a plug of cotton wadding.

"After hatching," says he, "the flies which had issued from the pupae sought to make their exit from the tube. They blew up their frontal vesicle and inserted it between the plug of cotton and the wall of the glass tube, endeavoring thus to open a passage way. The vesicle could plainly be seen to expand and then to contract. This action continued for five or six hours at the end of which time, under the influence of the phenomena of oxidation which occur, the chitin which covers the body assumed a deeper tint of brown and became more tough and resistant. The contractions of the frontal vesicle became less frequent and less rapid, until a moment occurred when the vesicle expanded for the last time, but was too stiff to contract, and, therefore, remained in the form of a small protuberance which finally became an actual horn."

Here then we have another case in which the chitin is shaped into a definite form while still plastic, but this time the form is of no use to the animal.

These two observations occurring almost simultaneously show how much there is still to be learned with regard to the metamorphoses of insects. A study of the mechanical conditions involved in the act of hatching would certainly reveal numerous facts of the same kind and throw much light upon these questions of mimetism and of adaptation upon these problems which are still so obscure and often so poorly formulated.

# Artificial Siamese Twins*

## Remarkable Results of the Experimental Union of Two Animals

### By Dr. Max Heyde

THE term "Parabiosis" is the name given in 1908 by Sauerbruch and Heyde to a form of experiment in which two animals of the same kind were united by means of an operation. The technique of this artificial union was managed as follows: The skin of the animal was split along a line running along the right or left flank from the upper foreleg to the hollow under the shoulder, and the skin was then separated from the tissues beneath so as to be movable. In most of the experiments the abdomen was then opened and the edges of the peritoneum sewed together in the usual manner of an intestinal anastomosis. In another series of experiments the investigator avoided this operation and contented himself by making a continuous lateral seam between the muscular layers of the rump and uniting the edges of the skin above and below this union of muscles. It was found unnecessary to make use of a bandage to retain the position, all that was required being to keep the two animals for a short time in a narrow cage.

The healing of the wound thus made occurred in from eight to twelve days. In certain cases where there had been a neglect of the proper conditions there occurred sloughing off by means of suppuration, and in some instances this made its appearance even after a week of apparently good results. From a histological point of view the healing of the wound was remarkable for the comparative strength of the granulation tissue formed upon each side. This fact is probably to be referred to the effect of a foreign body. After a longer duration the parabiosis exhibits only a narrow white scar at the place of union, which can be recognized in a microscopic section by means of a slight sub-epithelial lymphocytic infiltration and by the lack of the hair follicle and its glands. In the earlier stages of the process of healing a direct uniting can be observed taking place between the ends of the capillaries of the two animals. It was observed, too, after the separation of the living animal from a partner which had died, in which case a little bit of the tissue of the dead animal had been retained, that there was some genuine bleeding from the blood vessels in the neighborhood of the place of union. The union between blood vessels is shown with especial beauty in the injection preparations made by Goldmann and Zapelloni, so that there can be no doubt of a direct communication between the blood vessels in spite of the opposite view held upon this point by Morpurgo, Ranzi, Ehrlich, and others.

A union by means of the lymphatics is incontestable. Furthermore, there is a direct exchange of the fluids of the body between the two animals in the case where the abdominal cavities are united. Finally, it is possible that there is also a certain amount of diffusion from the capillary loops. On the other hand, nerve connections are entirely lacking, it results from this that these series of experiments are chiefly adapted to throw light upon pathological conditions upon questions concerning some toxic effect, where the reflex actions are excluded.

The united partners, therefore, form to a certain degree a single individual similar to the occasional freaks observed in nature, such as the Siamese twins, or the Blaczek sisters, whose case attracted general interest some years ago by reason of the pregnancy of one of the sisters.

All these experiments may be considered as falling in general under the head of grafting of tissues, and their final consequences represent the grafting of an entire organism upon another instead of a limb, a tissue or an organ. But these experiments of ours differ from all former ones by reason of the fact that by means of this parallel union between two organisms we obtain a means of investigation assisting us in the study of the widest variety of problems in the realms of clinical and experimental physiology and pathology.

It was not by mere chance that we were unable to carry these experiments further. At that time the knowledge of the conditions required for the successful transplantation or grafting of animal tissues and organs was still very limited. It was especially true that the conditions involved in experiments upon the usual animals employed for research, appeared considerably more complicated than in the case of lower forms of life, among which analogous experiments have often been conducted by zoölogists such as Korschelt, Joest, Correns, and others. Indeed, it is not very long ago that the possibility of transplanting tissues of a different kind from an animal to a human being was seriously debated, as was also the question of heterogeneous blood transfusion. Growing experience, supported by careful observation (Landois), has indicated the futility and even danger of such practises. Recent studies have shown us that heteroplastic experiment is practically never successful, while homeoplastic experiment, in the case of the grafting of tissues from one human being to another, is only occasionally successful. As a rule it far more often happens that the transplanted portion perishes and is either absorbed or sloughed off by means of granulation and suppuration. (Upon this point the interested reader may consult Schorne. *Die Heteroplastische und homoioplastische Transplantation.* Springer, Berlin 1912). Sometimes indeed in such cases, there is an injurious effect in the form of

*Translated for the *Scientific American Monthly* from *Die Naturwissenschaften* (Berlin), February 5, 1915.

a toxic action upon the grafted subject. This fact is probably to be explained by modern views as to the chemistry of albumens and the use of serums. These teach us that the higher organisms represent thoroughly individual biological entities, which refuse to permit any heterogeneous element to remain in their community of cells. However, these limitations due to individual peculiarities have been broken down in a very remarkable manner by means of our series of experiments in parabiosis. By means of this we succeed in forming a definite union between two of the higher animals for a long period of time.

It follows as a necessary result of this experimentally obtained condition that after the healing of the wound the animals thus connected must exert a mutual influence upon each other. From the anatomical and physiological point of view they remain separate individuals so far as their special functions are concerned, yet at the same time they constitute a new individual entity.

Attempts have not been lacking to make this union even more intensive by making use of the modern methods employed in the surgery of the blood-vessels. Not only Hedon, but more especially Enderlen and his collaborators have experimented along this line. Particularly interesting was the discovery that after the uniting of the artery and the vein at the neck no reciprocal toxic action of the companions was perceptible. If a thrombosis occurred at one point of the seam one of the animals lost all its blood to the other. Enderlen considers it improbable that there is a homogenization of the two individuals in the sense that biological differences in the plasma of the cells of the body are wiped out. But it must be remembered that in these experiments the duration of the union was very brief. The mutual interdependence of the two animals was exhibited by various phenomena worth mentioning. The death of one inevitably caused the death of the other. A sloughing off of the dead from the living by means of suppuration never took place. Such phenomena as increasing weakness, signs of irritation, and even at times convulsive movements (cramping) are to be regarded as due to the absorption of the toxins formed. This corresponds to the fact discovered that various substances when introduced into the body of one of the partners soon began to take effect in that of the other.

Another thing observed was that after such artificial Siamese twins had been united for some time serious disturbances of nutrition took place which were entirely independent, as Morpurgo has shown, of the food taken. They are first exhibited in the differing rate of growth of the two components. Later grave alterations occur. While one of the partners develops with remarkable rapidity the other displays signs of intensive starvation. The layer of fat disappears, that of muscles grows continually weaker, until finally the feebler partner resembles a mere appendage upon the stronger one. Morpurgo and Schoene remarked the same thing. The former observed in a male and a female rat thus joined, and which previously exhibited little difference, that 19 days after the operation the stronger animal was 11½ cm. long. The skull of the first was 38 mm. long and 20 mm. wide, while that of the second was only 34 mm. by 16 mm.

These observations are all the more remarkable since a primary difference due to the taking of different amounts of food was carefully avoided. Accurate experiments by Morpurgo and Lombroso have proved that aside from a slight exchange of nitrogenous substances a reciprocal mingling of nutritious materials does not take place. It was always found, too, that the duration of life and the loss of weight in a starving partner did not differ from the same phenomena in a starving individual not thus united. The fact of this strikingly different rate of growth, therefore, must be regarded as connected with the condition of parellelism, as has sometimes also been found the case in instances of human freaks. In these likewise we often see the state of health grow continually worse, while the other develops with uncommon vigor. In such a case the well-developed partner behaves like a parasite upon the weaker member of the union.

Ehrlich, Sauerbruch and Heyde have sought to explain this surprising state of affairs by means of the researches with regard to *athreptic immunity*. According to this view the phenomena can be explained by supposing that the animal which is the stronger one to begin with draws towards its own body certain substances required for its development—perhaps also the elements of nutrition in general—and thus to a certain degree passes sentence of death by starvation upon its companion. But even if we admit this possibility to be correct it by no means explains the frequent occurrence after a short time of violent disturbances of health, especially in rabbits and guinea pigs, which exhibit all the symptoms of a case of acute poisoning.

It is noteworthy in this connection that, according to the researches of Eller, the serious clinical symptoms which appear include alterations in the blood which must probably be ascribed to toxic influences. Such cases give the impression that the two animals are not biologically suited to each other. Differences in the composition of the albumen and a high degree of sensibility with respect to intestinal (parenteral) assimilation of such substances may probably be looked upon as the cause of such pathological symptoms. As to whether any anaphylactic effect is concerned herein cannot certainly be stated at the present time.

In order to exclude these biological differences between two parabiotic animals so far as possible, thus avoiding one source of possible ill success Sauerbruch and Heyde advise the experimenter to make use as far as possible of animals of the same sex and the same litter. In any case they hold that these precautions lead to better and more uniform results.

### CHIEF FEATURES OF THE SERIES OF EXPERIMENTS

Taking the idea of transplantation or grafting as our starting point it became our first object to discover by means of this parallelism the extent to which the original condition or disposition of one of the two companions could be transferred to the other. Of special importance appears the question whether a definite alteration can be produced in a given organism by uniting it with another. If this be true it might be hoped that surgery would gain assistance from parabiosis. However, it has not yet been possible to come to any definite conclusion upon this point. To begin with the idea suggested itself to test in this manner the conditions required for healing in the case of grafted pieces of skin, but decisive results have not yet been obtained by Schoene in experiments along this line.

Under the same head fall very interesting experiments with respect to the possibility of transferring immunity from cancer or susceptibility thereto. At the time experiments made by Krauss, Ranze and Ehrlich showed that in the case of parabiosis between a rat having a tumor and a normal animal the latter did not become affected. Albrecht and Hecht also found that parabiosis exerted an inhibiting influence upon the growth of a tumor in a mouse.

Lambert proved that an animal might be entirely transformed by long continuation of the parabiotic condition. Mouse tumors which ordinarily do not grow upon rats exhibited an excellent development upon rats joined to mice by parabiosis.

A number of other investigators have sought to discover to what extent disturbances in the progress of specific organic processes in one partner can be recognized in the other. Especial efforts have been made along this line in the study of disturbances occasioned by some injury or alteration of the internal secretions. Most important of these experiments are those concerning compensation in the case of the kidneys as carried out by Morpurgo, Sauerbruch and Heyde, and their collaborators, Jehn and Birkelbach. These experiments have done even more to explain the cause of uremia than the fact demonstrated by Morpurgo, that in the case of two united

rats the kidneys of one partner are capable of functioning for the other partner for months at a time. We cannot here elaborate this difficult chapter of our experiments, but will merely mention that they involve interesting discoveries with regard to the formation of oedemas, the cause of the hypertrophy of the heart and the problem of the internal secretion of the kidneys.

Sauerbruch and Heyde have also tried to find out whether it was possible to find an explanation of the beginning of birth pangs by studying the process of parturition in the case of two animals thus united. In the course of these investigations they made the surprising observation that shortly before the beginning of the pregnant animal's throes, the normal animal became extremely ill, and, indeed, perished in convulsions while the pregnant animal remained well. The investigators came to the conclusion that at the end of the period of pregnancy certain substances, probably of a specific nature, make their appearance, which are non-poisonous to animals in an advanced state of pregnancy, but are extremely toxic to normal animals, occasioning a violent death. They believe too, that these specific substances are capable of occasioning abortion at the beginning of the period of pregnancy.

Under the same head, finally, are to be classed the experiments made upon frogs by Harm with respect to the production of secondary sex characteristics. Harm based his investigations upon the hypothesis that the genital glands may secrete substances which are of importance with respect to the development of definite sex characters. He also studied the problems as to whether the influence of the testicle upon the phenomena of rut depends upon an internal secretion. In these experiments he united a normal animal with one which had been castrated. He thus demonstrated that certain phenomena of sex which are lacking in ordinary castrated animals, such, for example, as the yellow color of the fatty bodies and the clasping reflex were retained in the parabiotic castrate. On the other hand the atrophy of the glands, as also the tubercles of the epidermis, the so-called "thumb callouses," were not prevented.

While the experiments described above have concerned physiological problems rather than pathological ones, at the same time they have thrown light upon the cause of death from uremia, from severe burns, and from contusions. These experiments alone have been able to give a definite answer as to whether temporary pathological symptoms are to be referred to a reflex or to a toxic action. The proof of the latter is shown by the illness of the second partner which had not been artificially injured. These results were particularly important for the understanding of the causes of death from burns (Heyde and Vogt) as also death from intestinal stoppage (Sauerbruch and Heyde) which were formerly attributed to various causes, reflex action especially being responsible for the first symptoms of disturbance.

We may also mention briefly the work done in this manner with regard to the origin and transference of poisons of an external nature, the transferability of the tuberculin reaction or of anaphylactic poisoning and the formation of anti-bodies (Friedburger).

I trust I have succeeded so far as it was possible within such limited space in proving that the series of experiments made possible by parabiosis form an excellent means for the study of weighty problems—a means capable of leading to other important conclusions.

# Turtles, Terrapins and Tortoises

## Reptiles Whose Flesh and Eggs are Prized as Table Delicacies

By May Tevis

Photographs from the American Museum of Natural History

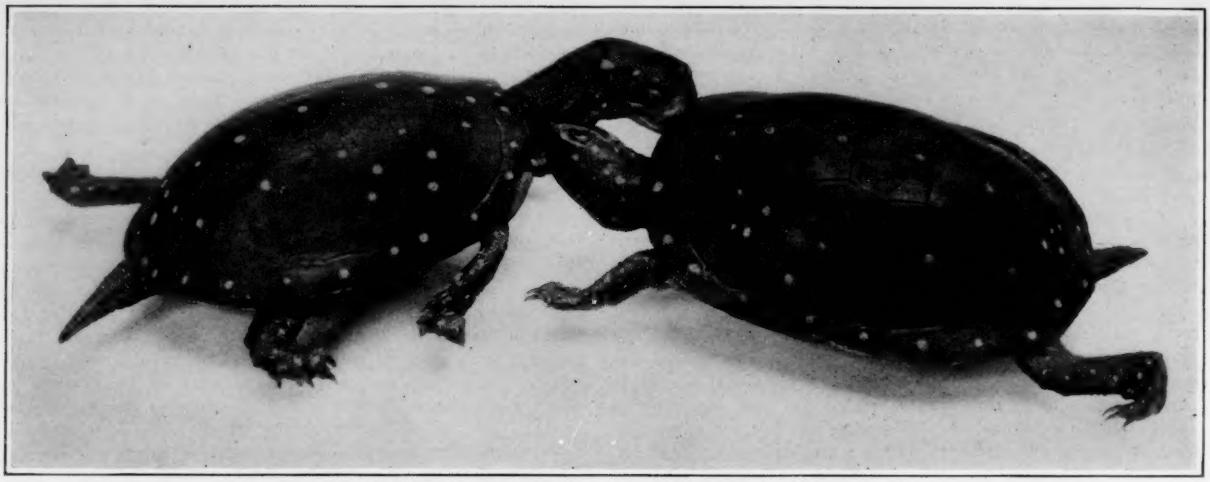
A GOOD many people doubtless will be rather startled to hear that turtles and their relatives, the terrapins and the tortoises are really reptiles. Most persons regard snakes with both fear and abhorrence, partly because of the deadly venom so many of their tribe possess, partly because of their sly, surreptitious methods of attack, and partly no doubt, because of subconscious associations connected with the original indiscretion of Mother Eve. Turtles, on the contrary, are generally regarded not merely with tolerance but even with esteem and affection, and this not merely because of their succulent appeal to the palate but likewise through subconscious associations somewhat more obscure in character. Whatever the reason may be, the turtle family has for centuries been held in high regard in many parts of the world. Perhaps this is partly because of their very solid and dependable structure. Is it not in the Upanishads that the world was represented as resting on the broad and steady back of a great turtle—surely a more dependable basis of support than even the mighty shoulders of Atlas? Then, too, these creatures enjoy a tremendous reputation for steady determination of purpose and unflagging energy in carrying it out, as witness the ancient fable of the hare and the tortoise. In short, they are looked upon as symbols of the eminently desirable virtues of patience, prudence, and perseverance. The writer has in fact seen these qualities amusingly represented in baby loggerheads just out of the shell, scrambling up through the warm Florida sands which form their incubator, and heading straight for the ocean in spite of various attempts to divert them or bar their way with obstacles. And who that loves his Uncle Remus can fail to have a kindly feeling for old Brer Terrapin?

Then, too, the majority of people consider the idea of eating the flesh of reptiles as being repellent and even disgusting, whereas the flesh of many members of the turtle family is a highly prized delicacy. Green turtle soup is famous all over the world and terrapin are fairly worth their weight in gold, selling even before the war at the rate of $75 a dozen for specimens 8 inches long (according to Mr. Dittmar, though the writer has found small ones recently at 75c.), which makes it amusing to recall that they were once so plentiful in the waters of the Delaware that the slaves upon the nearby Maryland plantations petitioned for relief from a too constant diet of venison and terrapin.

However, turtles, terrapins and tortoises are true reptiles according to scientific definition, since they are cold-blooded vertebrates which breathe by lungs throughout their whole existence and not by gills during a part of the time as do the likewise cold-blooded and vertebrate animals, frogs, toads and other Batrachians. Unlike Batrachians they undergo no change of form, coming from the egg in the same form which they retain throughout their lives. Furthermore, the skull of these animals is joined to the backbone by a single rounded knob or condyle, which is characteristic of reptiles as well as of birds, whereas in Batrachians as well as in mammals there are two of these rounded knobs or condyles. Again in the great majority of reptiles the skin is covered with scales or shields, while in most Batrachians it is naked.

### CLASSIFICATION.

In the preceding paragraphs I have used the word turtle somewhat loosely to include their congeners, the terrapins and the tortoises, and the word turtle is, in fact, generally so used in this country. Strictly speaking, however, it is better to confine the word turtle to those members of the Chelonia



WAX CAST OF A PAIR OF FIGHTING SPOTTED TURTLES

(Greek, *Chelonium* = a shield) which live exclusively in water and possess paddle shaped limbs; the purely terrestrial members of the Chelonia having club shaped limbs, are properly called tortoises, while those which live both on land and in water and possess an intermediate form of structure are terrapins.

The body of these animals is protected by a bony shell, usually coveed with horny shields, into which the head, neck, limbs, and tail may be retracted. This shell is composed of numerous bones, the principal being expansions of the vertebræ and ribs, forming the carapace, or dorsal buckler, the neck and tail being the only movable portions of the spinal column, and clavicles and abdominal bones forming the plastron or ventral buckler. The carapace and plastron are usually connected by a lateral part known as the bridge. Both the bony plates and the horny shields on the shell afford excellent characters for the purpose of classification.

In some tortoises and terrapins perfect hinges of elastic ligament are formed across the plastron, as in the so-called Box Tortoise, and either the anterior or the posterior lobes, or both, as the case may be, are movable and close up the shell. In the genus *Cinixys* a similar hinge is situated across the carapace, the hinder part of which is movable.

Regeneration of lost parts does not take place, although, as Gadow has shown, the injuries to the shell are made good by new growth of bony and horny tissue, after the dead portion has been cast off.

A tail is always present, but differs much both in length and structure, according to genera and species, this organ being sometimes covered with horny or bony tubercles, while in many the tip is provided with a sharp, nail-like spur. The toothless jaws are covered with cutting horny sheaths which may be serrated and constitute pseudo teeth. The neck, which varies much in length, may be either completely or only partly withdrawn into the shell, in some forms simply sideways (*Pleurodira*), or by a sigmoid curve in a vertical plane (*Cryptodira*). The eye is rather small and protected by an upper and lower lid, and a transparent membrane (the nictitating membrane), which moves horizontally; the pupil is always round. The sight and senses of taste and touch are well developed, that of hearing, however, is very imperfect, especially among aquatic forms, some of which are devoid of an exposed tympanum or ear-drum.

All tortoises, terrapins, and turtles lay eggs which may be round, oval or elliptical, and are generally hard-shelled; marine turtles, however, produce eggs, the shell of which is leathery instead of hard; they are always buried in the ground and hatched by the heat of the sun. Hibernation takes place in the temperate zone, the period varying in length according to the climate. Aquatic species generally hibernate at the bottom of the ponds or rivers they live in, or in the mud on the banks, while the land forms secrete themselves in the earth and sand, a few constructing regular burrows which may extend to a depth of several feet.

The food varies according to the structure and the mode of life. Land forms are vegetarians, those frequenting the water are either carnivorous or herbivorous, a few only living on a mixed diet.

Tortoises are remarkably long-lived, the giant forms of the Aldabra and Galapagos Islands attaining an age unparalleled by any other animal.

The order is not a very large one, the number of species of Chelonian amounting to only just over 200.

### LEATHERBACK TURTLE.

The *Dermochelys coriacea*, of the family *Sphargidae*, is the only representative of the suborder. It is the largest of living chelonians, and differs from all other turtles, terrapins, and tortoises in that its vertebrae and ribs are entirely free, and not fused with the carapace. The body is protected by a shield of small mosaic-like bony plates, covered with a very thick layer of leathery skin, which, except for the presence of a number of longitudinal ridges, is in adult specimens perfectly smooth; in the young it appears rather tuberculate. The limbs are paddle-shaped flippers without claws, giving the animal great swimming powers, and enabling it to venture far out to sea. In color it is dark brown, often more or less distinctly spotted with yellow or looking as if splashed with whitewash.

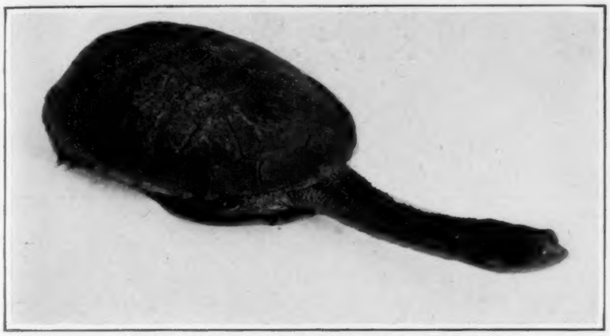
This creature has been considered to represent, so far as its vertebral column is concerned, the primtive type out of which the ordinary tortoise has been evolved says Boulenger, it being believed that the ossifications underlying the skin have gradually become fused with the bones of the skeleton to form the shell of tortoises and turtles proper. Others believe the *Sphargidae* to represent an ultra-specialized type evolved out of the turtles.

The Leatherback Turtle has a world-wide distribution, and is, in fact, a pelagic animal, straying to very distant localities, occasionally visiting the coast of Great Britain. In spite of its wide range it is by no means common. Numbers have been seen, however, off the coast of Tenasserim, and at the entrance to the Klang Straits, where they gather in order to deposit their eggs, each female depositing some three or four hundred.

The strength and pugnacity of this turtle are indicated by the following account by G. W. Gourley, of the capture of a specimen at Santa Barbara in the year 1905.

"The turtle was first seen swimming on the surface about two miles off shore. I went after it, accompanied by a boy,

in an eighteen-foot sailing boat. On approaching the turtle I dropped the tiller and got forward with the gaff hook, swung over the side, and got the hook fast in the leathery part of the neck. He immediately sounded, and ran out the full length of the line—about two hundred feet—towing the boat about half a mile farther out to sea. He then came to the surface and we pulled up close to him again. When he caught sight of the boat he turned and came towards us



AUSTRALIAN SNAKE-NECKED TURTLE

and threw his flippers over the gunwale of the boat, nearly capsizing her. I climbed up on the upper side, and shoved him off with an oar, the end of which he grabbed and bit off like a piece of cheese. His movements were very swift; using his fore-flipper he could turn almost instantly from one side to the other, and his head would project about eighteen inches from the body. I succeeded at last in throwing a noose over his head, and later, by attracting his attention in the opposite direction, got ropes round both flippers, finally having five lines on him, and started to tow him towards the shore. We were from 11:30 A. M. until 4 P. M. in finally landing him. When about half-way to shore he suddenly turned, and made a break out to sea, towing the boat stern first, with all sail drawing full, for several hundred yards, with little effort. He emitted at intervals a noise somewhat resembling the grunt of a wild boar."

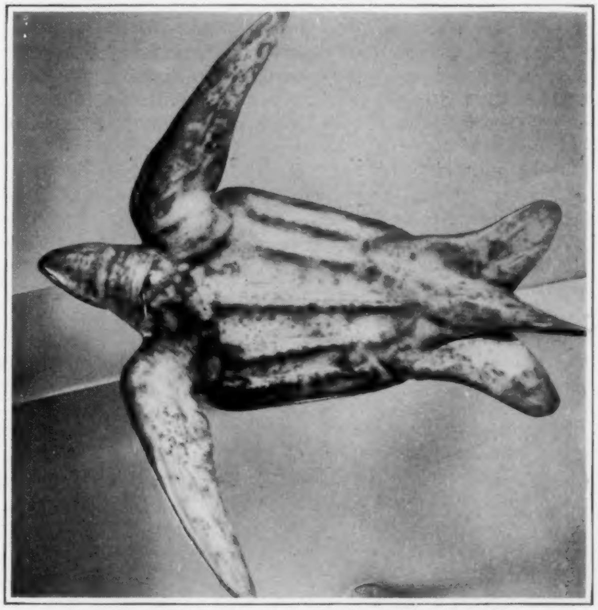
The largest specimen on record is over eight feet in length and weighs just over 1,500 pounds.

*Snapping turtles.*—Snapping turtles, sometimes called alligator turtles, have enormous heads, strongly hooked jaws, a long tail, a chin provided with fleshly appendages, and a very small cross-shaped plastron. One variety, *Macroclemmys*, sometimes attains a length of nearly six feet. This turtle while sometimes found in the southern states is most abundant in the Mississippi and the streams which flow into it. It has one very striking peculiarity, namely, a number of white fleshy appendages of the mucous membrane situated just in front of the tongue, which, the mouth of the creature being kept open, when in the water, are moved in such a manner as to simulate living worms, with the evident object of attracking the fish it lives on.

All these turtles are notorious on account of their savage dispositions. When annoyed they rise on their hind legs and turn almost complete somersaults in their efforts to bite. According to Holbrook they live at the bottom of stagnant pools or rivers of sluggish motion, occasionally coming to the surface with the rip of their snouts elevated, the other parts concealed, and in this manner float about aimlessly; descending to the bottom again when disturbed. They are much esteemed as an article of food, and large quantities, at least in North America, are brought to market. They are common in sea-food shops in New York City. They do exceedingly well in captivity, two "Snappers" in the collection of the Zoological Society in London, received nearly fourteen years ago, are almost as ferocious as on arrival, says Mr. Boulenger, the director, and will still occasionally seize upon walking-sticks and such articles as may be offered them "for the purpose of inducing them to show off their uncontrollable tempers." These specimens are fed exclusively on meat. In their native land they feed principally on fish and small waterfowl.

In the family *Cinosternidae*, popularly known as mud terrapin, the anterior and posterior lobes of the plastron are movable and connected with the central part by hinges, so that their oval-shaped shell can be partly or completely closed. The mobility of the plastron varies considerably to species and with age, for, as in the case of all terrapins with hinged plastrons, the mobility is not so marked in the young. The species most frequently seen in captivity are the Pennsylvanian mud terrapin, C. *Pennsylvanicum;* the stink-pot mud terrapin or Musk Turtle, C. *Odoratum;* and the blood-stained mud terrapin, C. *Cruentatum*. The two former are distributed throughout the Eastern State of North America, while the latter is confined to Central America.

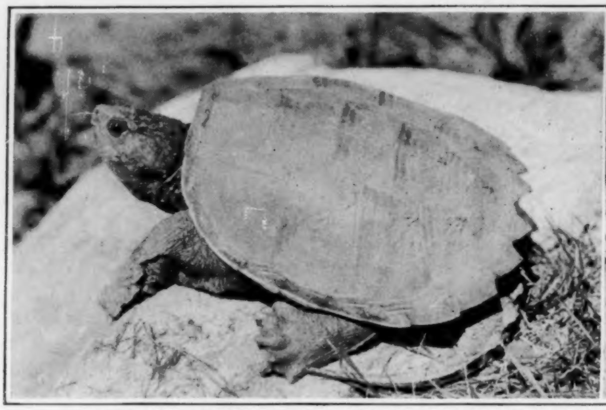
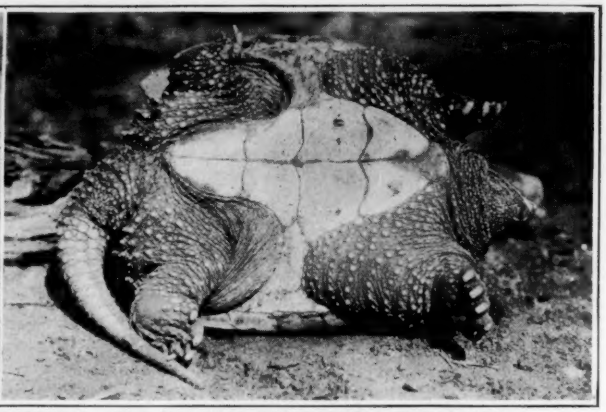
In C. *Pennsylvanicum* and C. *Cruentatum*, the plastral lobes are freely movable; the plastron, however, in the former species, is small, and consequently does not close up completely against the rim of the carapace, as in the case of the latter. The end of the tail is provided with a horny, nail-like appendage in both sexes in C. *Pennsylvanicum*, it is present only in the female in C. *Cruentatum*, and is absent in both sexes in C. *Odoratum*. In the latter species the plastron is considerably narrower and smaller than in the two preceding, and the lobes are only feebly movable. This terrapin derives its name from the fact that on being alarmed it emits from certain glands a remarkably pungent and most disagreeable odor of musk.



VENTRAL VIEW OF A LEATHER BACK TURTLE

The members of this family, none of which exceed a shell length of six inches, are found in muddy ponds or ditches, feeding on small fish and tadpoles. They are said to be very treacherous creatures; when handled they immediately withdraw into their shells, firmly closing them; they do not remain inside for long, however, for after a few seconds they dart out with unexpected rapidity, their mouths wide open, ready to inflict a severe bite with their cutting jaws. The back of the legs of the male in some of the species bears two patches of horny tubercles, and by rubbing these against one another stridulating sounds are produced very similar to those made by grasshoppers.

The widely distributed family *Testudinidae*, which embraces some 130 species, includes a number of strictly aquatic gen-

THE SNAPPING TURTLE NOTED FOR ITS SAVAGE DISPOSITION. THE VENTRAL VIEW SHOWS THE SMALL CROSS-SHAPED PLASTRON

era, as well as all the land tortoises, the passage from one form to the other being so gradual as to preclude any sharp definition. With the exception of Australia and Papussia, its representatives are distributed throughout the greater part of the world.

*Batagur* and *Hardella* are two closely related aquatic genera, represented each by a single species; the former, inhabiting Bengal, Burma, Siam, and the Malay Peninsula, is to be distinguished from the latter, which is confined to northern India, by the fact that its front limbs have only four claws, instead of the usual five. The limbs are very broadly webbed, somewhat approaching the paddle-shape. The tail is short.

The Baska Turtle, *Batagur baska*, abounds in the Ganges and its tributaries, and is occasionally caught out at sea in fishing nets. Although purely a vegetable feeder in its native waters, specimens in the London Zoo all develop a taste, we are told, for the bread, biscuits, and buns thrown into their tank by visitors. The eggs of this species, the collecting of which is a royal prerogative in Siam, resemble hens' eggs in size and shape.

*Hardella thurgi*, which likewise feeds solely on aquatic plants, is, according to Anderson, brought to Calcutta in large numbers during the cold months and sold to a low caste of Hindoos, who keep them alive in tanks, selling and eating them themselves. He gives the following account of the extraordinary manner in which they are captured: "A number of men, all but naked, collect together, each man being provided with a large bundle of green marsh grass neatly tied up in the form of a cylinder, measuring about two feet long. These men enter the water, throwing the bundles before them, which act as floats, and on which each man rests his chest as he gets beyond his depth. Then, one after another, they push away these floats, dive to the bottom of the river, and reappear generally with an example of *Hardella* obtained in the mud."

*Chrysemys* is a large genus distributed throughout North and Central America. The carapace is feebly convex, the plastron is immovable. Although eminently aquatic, frequenting rivers and ponds, and ditches in the case of *C. picta*, the painted terrapin, these terrapins often leave the water, and are most active on land. The soft parts as well as the shells are in most species most beautifully marked. In *C. ornata*, for instance, the head and neck are streaked with orange, while each costal and marginal shield is provided with a large yellow or orange ocellar spot. These markings are brighter and much better defined in the young than in the adult, where, in a good many cases, they disappear almost entirely. In *C. scripta* the sides of the head are ornamented with bright yellow, or yellow and pink bands. Mr. Hugh Smith has given an interesting account of the breeding habits of this species. The egg-laying season, it appears, is in June and July, and the eggs are laid in some cultivated tract, usually a cornfield adjoining water, the nests being made some distance away from the water, sometimes more than a hundred feet. The nest, which is shaped like a bottle, is made usualy in a sandy clay, above high-water mark, the hole being dug out by the female with her fore-legs. The size of the nest depends on the size of the animal, an average nest being four inches deep and four inches wide. The eggs, up to thirty-five in number, are laid at one time, and when the laying is completed, earth is scraped into and over the hole and packed lightly. The packing is accomplished by the terrapin's raising herself as high as possible on her hind legs, and then dropping heavily. As soon as the nest is covered over the terrapin withdraws to the water. If a terrapin is disturbed while making a nest or laying, she will abandon the nest. The young hatch in the autumn, but remain in the nest, where they hibernate until the following spring. On emerging they are about the size of a fifty-cent piece. This terrapin formerly supported a profitable fishing industry, but of late years nas become rather scarce, those caught being accidentally taken in fishing nets.

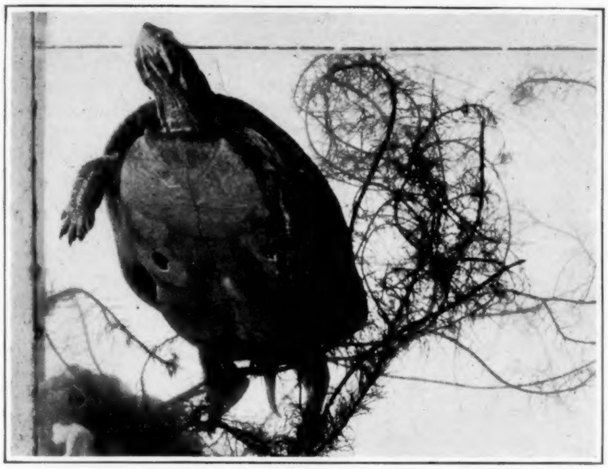
The European pond tortoise, *Emys orbicularis*, is distributed throughout the greater part of southern Europe, Algeria, Tunisia, and southwest Asia. In Central Europe it extends locally as far north as Central France, Holland, Prussian, and Poland. The coloration of the shell is subject to much variation; it is usually dark brown or black with numerous yellow radiating lines, or spots; the plastron is yellow and brown, occasionally entirely blackish brown. The head is black, with lighter dots, which are usually yellow, and in some males of a pale brown. The shell, which is oval in the adult, round in the young, is smooth, with a few well-marked ridges on each shield. The tail is as long as the shell in the quite young, two-thirds that length in adult males, and about one-half in the females.

The tortoise generally hibernates in the mud at the bottom of the pond or river towards the end of October. The lethargy, especially of those hibernating in shallow waters, is not very profound, and a little sunshine, even in mid-winter, is sufficient to awaken them from their slumbers. They resume their activity towards the middle of March, pairing in April, and laying up to a dozen oblong eggs in May or June. Adult specimens do well in captivity; they feed both on land and in the water, usually upon meat or fish, but will sometimes eat lettuce. The quite young are, however, exceedingly delicate, and generally succumb to pneumonia after a few months of captivity. The flesh of this species is said to be moderately good eating, and was formerly appreciated as a delicacy for "fish days" in the Roman Catholic parts of Germany.

Blanding's terrapin, *Emys blandingi*, is a North American species, closely resembling the European pond terrapin. The carapace, which is slightly more convex than in the latter species, is jet black, spotted with bright yellow. The plastron

is yellow and black. The head is brown above, yellow beneath. Like its European ally it is easily domesticated. It takes to land frequently in search of a change of diet, feeding on insects and berries.

In *Clemmys* the plastron is united to the carapace by bone and not by ligament as in *Emys*, from which it does not otherwise differ. The genus is represented in Europe, Africa, southwestern Asia, China, Japan, and North America. Two species are found in Europe, the Iberian terrapin, *Cl. leprosa*, which inhabits the Spanish Peninsula, Morocco, Algeria, and



PAINTED TURTLE IN AN AQUARIUM

Tunisia, and the Caspian terrapin *Cl. caspica*, restricted to southeastern Europe and Asia, from the borders of the Caspian Sea to the Persian Gulf.

In *Cl. leprosa* the carapace is dark olive; the plastron yellow. The head is olive, the sides being streaked with yellow, while an orange spot is situated between the obit and the ear. A number of yellow bands extend along each side of the neck. The shell seldom exceeds six inches in length. Its specific name is derived from the fact that the creature is subject to a gangrenous disease, when living in not sufficiently aerated waters, which gives the shell a leprous appearance.

*Cl. caspica* is more handsome, the carapace being elegantly marked with black-edged yellow, wavy markings. This and the preceding species are far more aquatic in their habits than *Emys orbicularis*, and, unlike the latter terrapin, never feed out of water. Freshly captured specimens of the Caspian terrapin emit, when handled, a disagreeable odor, which is due, as in *Cinosternum*, to the secretion of a pair of inguinal glands. When kept for some time in confinement, however, they lose this objectionable habit. Although reaching a length of about five inches, imported specimens rarely measure more than two, and, like most young terrapins, seldom thrive for any considerable time under captive conditions.

In *Cistudo*, the representatives of which are the true Box Tortoises, the plastron is connected with the carapace simply by ligaments, and is divided into two movable lobes, enabling the creature, after withdrawing its head, neck, limbs, and tail into the shell, to close it hermetically like a box. The digits are almost entirely free, being provided at most, with only a very short web.

With the genus *Cinixys* begins the series of entirely terrestrial types, the true tortoises, which are provided with club-shaped feet and webless digits, and in which the plastron is always united to the carapace by a broad bridge.

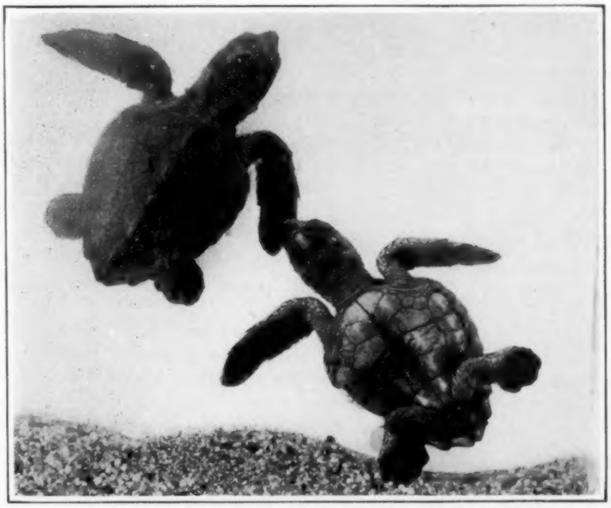
In this genus a remarkable modification of the shell takes place, the posterior portion of the dorsal buckler being hinged and movable.

The Gopher Tortoise, T. *polyphemus*, of Florida, is remarkable inasmuch as it lives in burrows, which it only leaves on very hot days. The burrows are excavated in the sandy soil by means of its front limbs, which are armed with abnormally long claws, with the help of the plastron, which is provided with a small spade-like projection. According to H. J. Hubbard the galleries descend at an angle of 35 degrees, and reach a vertical depth of about nine feet from the surface of the ground, measuring often as much as eighteen feet in length. The temperature at the lower end does not vary much throughout the year, not falling below 70 degrees F. in winter nor rising above 80 degrees in the summer. Once the tortoise has established itself in one of these burrows, it cannot be made to vacate or excavate a new home, but settles down for long periods, some of the burrows being known to have been inhabited by the same individual for as much as twenty-five years. The galleries, if abandoned, immediately become filled up with the shifting sand; they afford a refuge for various other animals, including opossums, raccoons, and owls. The Gopher Tortoise does not survive many months of captivity, making no attempt to burrow.

The Elephantine Tortoise, T. *elephantina*, is now nearing extinction in its native home, Aldabra, but of late years it has been introduced in the Seychelles, where it is now fortunately thriving under Government protection. The shell of large specimens measures five feet in length.

The South Albermarle, T. *vincina*, grows to an even larger size, its shell reaching over five and a half feet in length, such specimens weighing at least five hundred pounds. It may be distinguished from T. *elephantina* by the absence of the nuchal shield.

Some interesting notes have recently been published by the Governor of the Seychelles regarding the conservation of land tortoises in the island. The largest specimen of the herd measures four feet nine inches over the surface of the carapace, and is probably the largest living specimen at the present day. "Gordon," as the cretaure is called, shows likes and dislikes, and is very combative, having bitten many visitors who presumed on his apparent lethargy. The breeding season in the Seychelles extends from January to April, when the females lay their eggs in holes dug out by their hind limbs, and then covered over. The eggs, which are white, round, and the size of a tennis ball, vary in number from nine to twenty-five. The young hatch out in from 120 to 130 days, and work their way out of the ground; half the eggs are usually infertile, but in some years of great drought very few young appear, being apparently unable to reach the surface. Their rate of growth is exceedingly fast, since they measure, when four years old, nearly two feet in length. When twenty-five they are said to attain full growth.



A PAIR OF LOGGERHEAD TURTLES DISTINGUISHED FOR THEIR LARGE HEADS

These tortoises in the London Zoological Garden hibernate from the end of October to the beginning of March. They are fed chiefly on cabbage, of which they consume, during the hot weather, almost a bushel a week each. "One large Elephantine Tortoise is peculiarly untortoiselike in his taste, being extremely fond of the bread and buns which he receives from the visitors, whom, if provided with these dainties, he will follow round his enclosure, often attracting their attention by butting against the railing of his paddock."

The Green Turtle, *Chelone mydas*, enjoys world-wide fame, for it is from the flesh of this creature that the famous "turtle soup" is obtained. The heart-shaped shell is smooth, polished, and slightly notched and serrated behind. The head is large, somewhat compressed at the sides. The jaws are provided with very much serrated cutting edges at the sides, the lower beeing hooked in front. The shell attains a length of about four feet, such specimens weighing about four hundred pounds. Although fairly abundant in all the tropical seas, the great bulk of those received in this country are obtained from the West Indies.

"The eggs are deposited on the sandy shores of uninhabited islands. Before embarking on her parental duties, the female makes a thorough inspection of the beach where she has the intention of laying. Satisfied that the situation is appropriate, she digs a hole nearly three feet deep, with her flippers, and therein deposits some two hundred eggs. These holes are then covered over with sand and levelled down by means of the flippers, in such a manner that it is only with the greatest difficulty that their place of concealment can be discovered. The whole operation of digging, laying, and filling up lasts about a couple of hours, when the turtle once more returns to the sea, leaving the eggs to be hatched by the heat of the sun." After a few weeks the young turtles break through their egg-shells, lift up the sand, and, without the slightest hesitation, make straight for the sea. Although man is perhaps their chief enemy, enormous quantities of young turtles are devoured by large fish, and only a very small percentage reach maturity.

The food of the Green Turtle consists almost entirely of fish and marine plants.

The Hawksbill Turtle, *Chelone imbricata*, also a powerful swimmer, inhabiting all the tropical and subtropical seas, only coming to shore at the breeding season, derives its English name from its prolonged hooked snout. The carapace, the shields of which are more or less imbricate, is marbled yellow and dark brown. It is a somewhat smaller species than the Green Turtle, the shell of adult specimens rarely measuring more than three feet in length.

Although not edible, this animal is highly esteemed on account of its horny shields affording the substance known as "tortoise-shell." According to Sir Edward Tennant, the cruel method is employed in Ceylon of suspending the living turtle over fires, until the heat detaches the plates from the bones of the carapace, after which the creature is put back in the water, it being erroneously believed to return again with a regenerated shell. It appears that if the latter be removed after death the color becomes cloudy and milky, and therefore useless from a commercial point of view.

An interesting account of the fishery resources of the Philippine Islands, which contains some interesting information on this turtle, has been given recently by Mr. Alvin Seale. During the year 1909, there were exported from the Philippines 2,040 kilograms of tortoise-shell. While a small number of turtles are caught with hook, net, spear, or trap, by far the greater number are captured when they come to shore in order to deposit their eggs, the animals being killed without being given a chance to lay, a short-sighted policy, which, unless the turtles are protected during the breeding season, which is from May to August, will eventually result in the destruction of the fisheries.

In the Philippine Islands, it is satisfactory to learn that the method of removing the tortoise-shell from the animal's back, described by Tennant, is not resorted to, the shell in most of the islands being removed after the turtle has been killed, by immersing the carapace in boiling water until the shields loosen; another method is to bury the body in the sand for about a week, when the shields become detached. The quantity of tortoise-shell obtained from a single adult specimen varies in weight from five to ten pounds.

The Loggerhead Turtle, *Thalassochelys caretta*, is characterized by an enormous head. The carapace, which is very strongly arched, is uniform dark brown or black. The lower jaw is slightly hooked. Its range is even wider than that of either the Green or the Hawksbill Turtle, it being found much farther north, and being in fact not uncommon in the Mediterranean and neighboring parts of the Atlantic. It is of little value from a commercial point of view, its flesh, although not absolutely inedible, being far inferior to that of the Green Turtle.

Although in fresh water aquariums all these marine forms refuse to feed, and die of starvation in a very short time, they will live for many years under captive conditions if provided with sea-water, even in quite small tanks.

As we have said, the flesh of the loggerhead turtle is not very edible. However, the eggs laid by these animals are not only edible but very delicious. The writer has often gathered them on the coast of Florida, fresh from the nests. They are perfectly spherical, creamy white in color, and the "shell" instead of being brittle like bird's shell, resembles tough parchment in look and feel. The eggs are never eaten simply boiled so far as I know; the reason given being that the albumen does not solidify. This fact, however, I cannot vouch for personally, but I have eaten dozens of these eggs in the form of griddle cakes, puddings, etc. They are entirely free from any fishy or unpleasant taste or odor and are very nutritious. They are not only popular as an article of food among the natives of Florida, but they are also keenly enjoyed by various wild animals, including bears, opossums and skunks. So keen is the competition for these delicacies in fact, that one must make a very early start to obtain the prize.

When ready to deposit her precious burden the female turtle swims ashore at high tide and crawls straight up the sandy beach for a distance of several yards, where the nest will presumably be safe from the waves. She then excavates a hole, usually about a foot in diameter and perhaps 18 inches deep. In this a large number of eggs is deposited, usually ranging from 120 to 150 eggs. As will be seen such a nest is a find indeed, comprising several pounds of valuable food; consequently people living near the coast often make up "turtle egging parties" during the spring and summer months when the tide is right, in the hope of coming upon one or two turtle "crawls." The crawl consists of the parallel marks left by the creature's flippers as she toils her way across the sand. After depositing the eggs she fills the hole neatly, and then apparently whirls round and round. Consequently, at the end of each crawl, there is a sort of roughly circular whorl in the sand. The pocket of eggs, however, is by no means exactly in the center of this whorl, so that it requires considerable skill to locate it when digging up the whole area. Experienced hunters judge its location by the greater softness of the sand. I well remember, some years ago, walking up the Ormond Beach before that part of the world was as fashionable and as much frequented as at present—for two or three miles and finding several crawls, but in each case the nest was completely empty, the reason being very evident from the fresh bear tracks which led the way. Finally we came in sight of the bear himself and turned back, though he was undoubtedly in a very amiable frame of mind after just swallowing hundreds of the titbits we ourselves coveted.

Since the mother turtle never returns to look after her offspring, once having prepared for their proper launching into the world, many of them are devoured at a tender age, even when they have escaped being eaten in the form of eggs. There undoubtedly should be some sort of legislation to protect these

creatures, and it would be well to require the finders of the eggs to rebury a certain percentage of them in a fresh place where there are no tell-tale signs to reveal their presence. I have done this myself and been rewarded by the entertaining spectacle described above of the baby turtles scrambling out of their little nests and setting solemnly off for their first dip in the chilly waters of the ocean.

## HOW SPRING FLOWERS CAN BLOOM UNHARMED IN SPITE OF FROSTS.

IN studying the phenomenon of the chilliness of the ground during the night as a result of spring frosts, observers have usually confined themselves to recording the temperature observed immediately above the vegetation, woods, grass, herbs, etc., which usually covers the ground, but a Scotch investigator, Mr. T. B. Franklin, has recently attacked the problem in a much more thoroughgoing manner, basing his studies upon the assumption—which he has proved to be correct—that there is frequently a very great difference between the temperature of the ground itself and that of the air above it. This difference is chiefly due to the nature of the protective layer above the earth itself.

The cooling of the ground on a clear night is due to radiation, but the effects produced by this are at first counterbalanced by the conduction of heat, which brings toward the surface of the ground the warmth of the deeper strata. Thus when the earth begins to freeze the latent heat liberated by the freezing of the moisture must be radiated before a new fall in the temperature of the ground can occur. In other words, it is only the surplus of the radiation after the balancing of these two factors which is effective in lowering the temperature of the ground. Accordingly when the surface of the ground is dry and the conductivity is reduced, or when the temperature of the deep lying strata is already low, the ground is cooled much more rapidly by radiation.

It is obvious, therefore, that the temperature of the surface of the ground depends upon three factors:

1. The comparative humidity of the air.
2. The degree of dryness of the superficial layers.
3. The temperature of the subadjacent layers.

Mr. Franklin undertook to determine the comparative importance of these different factors. In order to calculate the power of conduction he measured the temperature at the surface at a depth of 10 cm. Between these two points the temperature usually is almost uniform so long as the surface does not freeze.

The results obtained admirably proved the correctness of the theory, but it was found that on clear, calm nights, when the stars of the fifth magnitude are visible the radiation of the ground depends upon the relative humidity, other factors such as condensation and evaporation, exerting but little effect upon ground temperature. The temperature of the surface tends to fall rapidly below the temperature at a depth of 10cm., by a number of degrees such that the conduction starting at this depth exactly balances the radiation. After this balance has been attained, the surface temperature cannot fall more rapidly than that of the stratum at a depth of 10cm., and consequently when there is a sufficiently high temperature of the subsoil frost is improbable. The difference of temperature between the surface and the depth of 10 cm., which would constitute an equilibrium between conduction and radiation is probably about 5.5°C.

3. In winter, at which time the ground is almost invariably humid, it possesses a uniform maximum conductivity, but it may rise to 11 degrees cent., after a dry period in the spring, or at the beginning of summer. These data seem to indicate that it will be possible in practise to predict a frost at night according to observations made in the afternoon with regard to the three factors mentioned above.

When the ground is covered with any substance which is a poor conductor of heat, radiation from the surface is considerably diminished on clear nights. Mr. Franklin made a series of observations concerning the minimum temperature of the surface of the ground when entirely bare and when covered with layers of different substances. These layers were each 12.5 mm. in thickness and consisted of well-crumbled loose earth, of cinders, of manure, of dead leaves, and finally of a natural growth of grass and moss. The maximum thermic efficiency of these five protective layers was as follows:

1. Crumbly earth, 1.7°C.
2. Ashes, 3.3°C.
3. Manure, 3.6°C.
4. Dead leaves, 4°C.
5. Natural grass and moss, 5.5°C.

During the winter of 1918-19, when these experiments were made it was found that the ground covered with either grass or moss never froze.

By covering the ground with a layer of ashes and placing a screen on top, Mr. Franklin succeeded in maintaining the temperature at 5.5°C. above that of the naked ground, thus equaling but not exceeding the protective effect of the natural covering of grass or moss.

On the slopes of ditches, or in the shelter of hedges and woods protected against the wind and against the effects of radiation by a layer of dead leaves, of grass, or of moss, it will be readily seen how the roots of spring flowers can thus pass through winter without being touched by frost. Even in December, when there is a period of warm rain to give the necessary heat to the ground, these plants will begin to send up their leaves and may be seen blooming at times, just when the winter is most severe. Thus Mr. Franklin saw a primrose which had been so stimulated by the mild weather of December, 1918, that it had made its way through the mossy turf above it and bloomed February 10, 1919. The leaves and flowers in the air, had at this time a temperature of 9.5°C. below zero, while its roots safely buried in the warm earth were 0.5°C. above zero. Thus there was a difference of not less than 10°C. between the roots and the flowers.

## VOLUNTARY DETERMINATION OF SEX BY MEANS OF CHEMICALS.

DURING the last five years certain experiments with respect to the determination of sex have been conducted in the Pharmacological Institute of the University of Frankfurt. The results obtained were eminently successful and were recently described by Dr. L. Adler, at a session of the Frankfurt Senckenberg Society. The investigator, Richard Hertwig, and his students are able to produce males from frogs, common brown frogs (*Rana fusca*), during the period of development by the application of heat of from 25 to 28 degrees cent. Under these conditions certain transformations take place. The same success was obtained by the use of eggs which have attained a state of hyper-maturity before being fertilized. Dr. Adler also discovered that the male frogs produced from such eggs exhibit transformations of the thyroid gland in a very high degree, and these largely correspond to the alterations observed in human beings occasioned by Basedow's disease. Another investigator, Gudernatsch, succeeded in obtaining 100 per cent of male frogs by feeding tadpoles with the substance of the thyroid gland. In fact, among 400 tadpoles thus fed there was not a single female.

Under the influence of heat a retrogression or degeneration of the thyroid gland occurs and by reason of this some of the effective substance contained by this gland is liberated and thereupon occasions the transformation of female organs into male organs. The chemical agent concerned in this reaction is iodide of albumen. Very curiously the males thus artificially produced all had uncommonly small weak legs.

Some experiments have been made with animals higher in the scale, but so far as the writer knows without much success. It must be remembered, too, that there is more or less danger connected with the use of the thyroid treatment.

# Microscopic Water Contaminators*

## Minute Organisms That Give Unpleasant Flavors and Odors to the Water Supply

By Morton Charles Kahn

Department of Hygiene, Cornell University Medical College

WE have all, at one time or another, encountered foreign flavors and odors in the water supply, both agreeable and repugnant. For the most part these are due to the presence and growth of microscopical plants and animals. Such effects, together with the presence of turbidity and color, are always looked upon with suspicion by the public, for there is nothing to which a community is more sensitive than something unusual in its drinking water or in its household supply, be it detectable by smell, sight, or taste.

Large and small flowering plants, commonly found in reservoirs and along sources of water supply, such as pickerel weed (*Pontederia*), water plantain (*Alisma*), eelgrass (*Vallisneria*), and many others, rarely cause trouble. While they may be a nuisance in a mechanical way, due to their abundance, or even by contamination since they furnish a place of rest for the more obnoxious forms, still in themselves they are harmless, and produce no direct effect upon water used for domestic purposes. It may be said that although a large accumulation of these plants undergoing the processes of decay, together with other decomposing organic matter, may produce unpleasant flavors and odors, this condition seldom occurs and if it does it is a comparatively easy task to rid a water supply of this trouble.

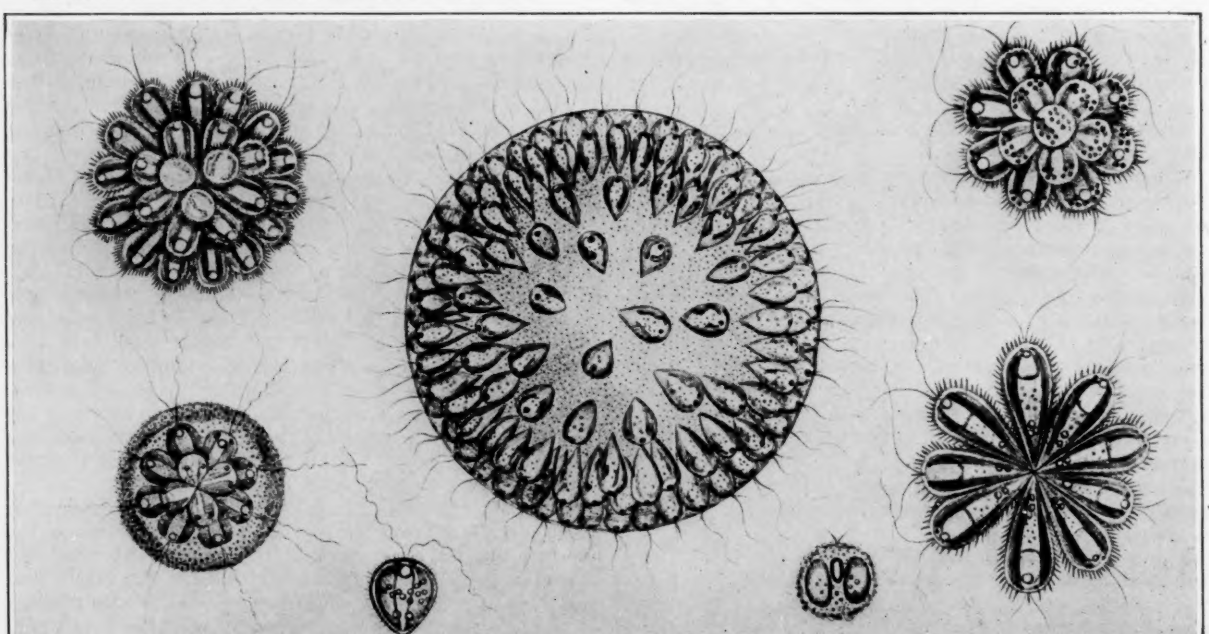
There remains one group of plants, the algæ, mainly microscopic, which is unfamiliar to most people and much too often neglected because it seems to possess no economic importance. This is a mistake, for these microscopical plants have a real influence on the general public welfare, in that they are direct causative agents for practically all of the bad odors and flavors in drinking water and, besides the bacteria and a few protozoans, are the only organisms which need be taken into account when considering the biology of drinking water from a hygienic standpoint. Some of the algæ may be seen with the naked eye, that is of course when they occur in vast numbers so as to form a scum on the water's surface. Most of them may be seen only with a microscope, and it is only by the aid of this powerful magnifying instrument that any of their individual structures can be studied. Their structure, too, for the most part, is very beautiful, forming one of the most fascinating fields of microscopy.

Let us first consider the diatoms, a great group of troublemakers belonging to the algæ. It is known that some of them give rise to serious trouble in the water supply.

Water inhabited by excessive numbers of these organisms most frequently develops a very disagreeable fishy odor. Some people think the odor like that of geraniums. Personally, however, I think it far less agreeable than the fragrance of this common garden flower. The specific types of diatoms which cause the disagreeable conditions are : *Asterionella*, responsible for the distinct fishy smell, and *Tabellaria*, *Meridion*, and *Diatoma*, when they become numerous. When sparse, on the other hand, they are possessed of a distinct aromatic principle, which is not considered disagreeable. Diatoms are exceedingly troublesome when contained in water used for laundry purposes, or for the manufacture of paper. This is due to the fact that they contain a greenish pigment, which stains articles coming in contact with it.

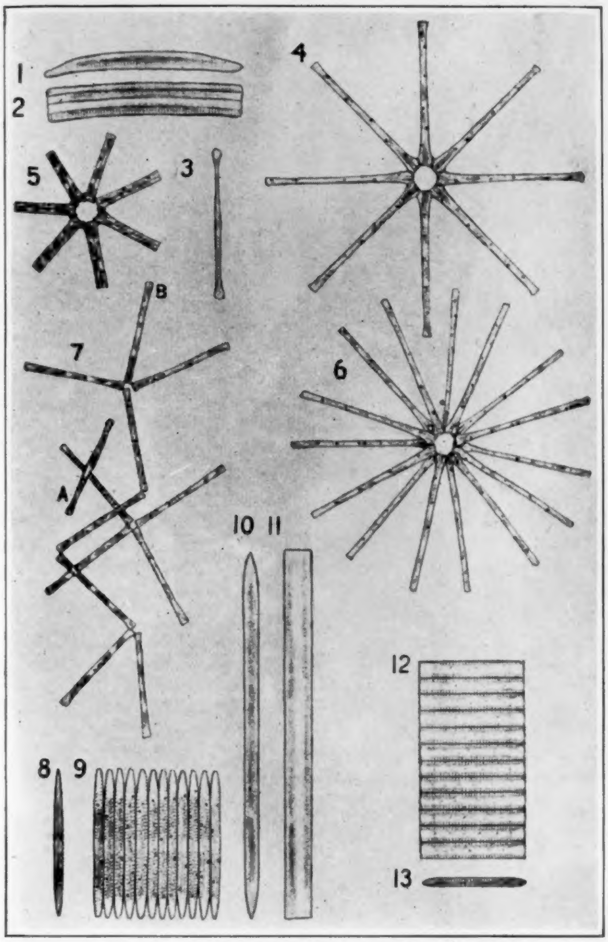
Structurally a diatom is very beautiful. It may be described as resembling a glass box made up of two halves, one fitting tightly within the other, the walls being strongly silicified. Diatoms are not without their redeeming features, for it is this silica contained in diatomaceous earth that makes it valuable as a polishing powder. Earth containing diatomous

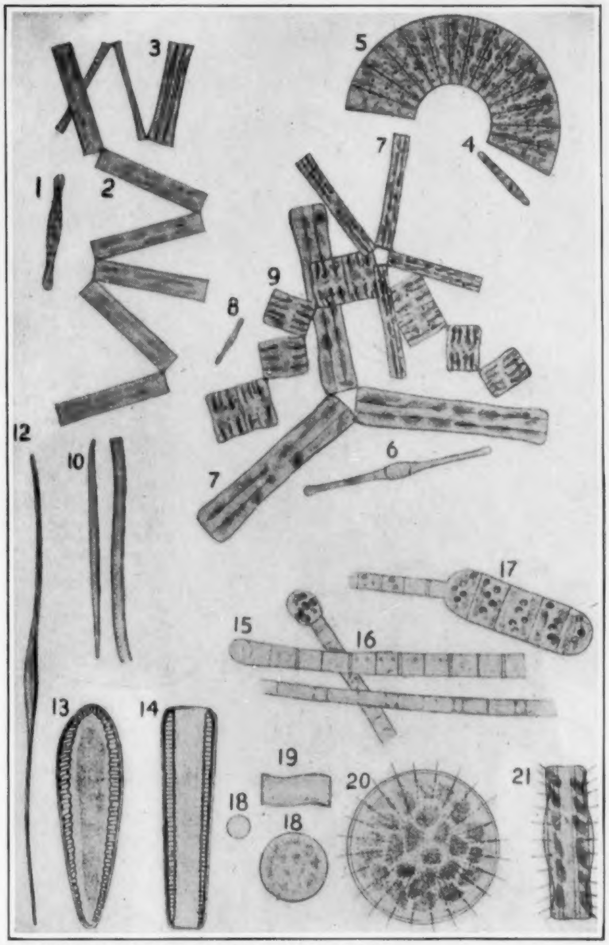
*Reprinted from *Natural History*, January-February, 1920.



SOME INTERESTING MICROSCOPIC CONTAMINATORS OF PUBLIC WATER SUPPLY

The *Uroglena* (center illustration), which are claimed alike by botanists and zoölogists, grow in colonies, single-celled bodies embedded in the surface of a gelatinous sphere. Only the slightest pressure is required to break the delicate structure, liberating an oil with a fishy odor. The other forms in the illustration are *Synura* and *Syncrypta*. Bad odors, especially cucumber odors, have in the past been traced to *Synura*. Even so few as five or ten colonies to a cubic centimeter will cause a perceptible odor.





MICROSCOPIC DIATOMS WHICH CAUSE DISAGREEABLE ODORS IN DRINKING WATER

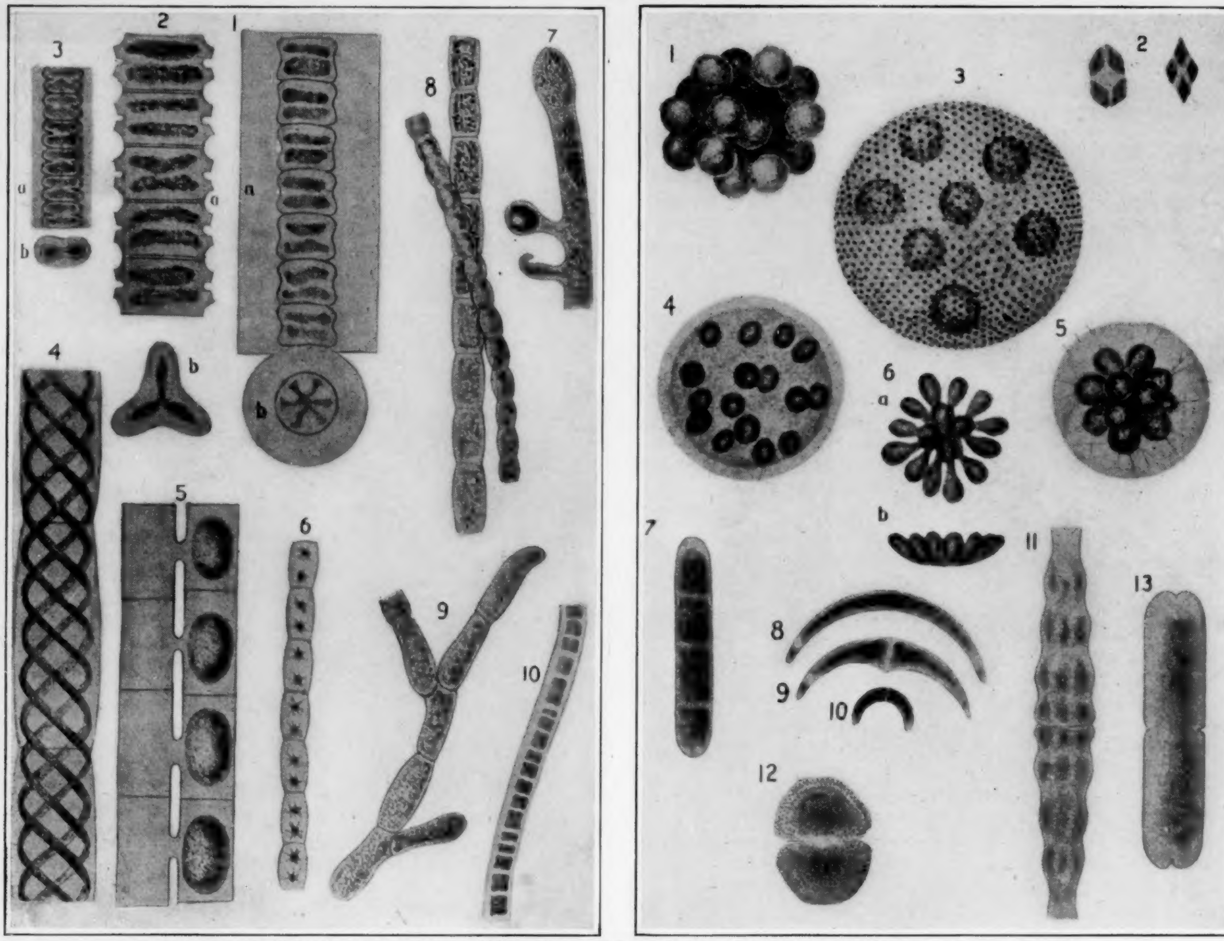
Seen under a microscope, a diatom is geometrical in design, with two transparent valves, fitting one into the other like a shallow glass box and its cover. The valves are variously marked with points or grooves so minute that from several hundred to several thousand occupy a millimeter. These increase the friction of the diatom with the water and tend to prevent it from sinking—for a diatom is heavier than water, yet must float near enough to the surface to get sunlight for growth. The illustrations show common diatoms in both valve and face views; 3 and 4 (at the left) are *Asterionella* which may give a fishy odor to water; 6 illustrates the rapid multiplication of *Asterionella* by division. It is said there are nearly 10,000 species. Some species have a spring and fall period of maximum growth, such are *Synedra* (8-11), and in the illustration at the right *Diatoma* (1-3) and *Tabellaria* (6-9).

remnants is used to some extent in the manufacture of dynamite. Diatom shells form no mean portion of certain of our well-known brands of tooth powder, and last, but by no means least, the living marine types form an important part of the diet of some of our food fishes.

The methods used for multiplication by these members of the Diatomaceæ, are unlike anything of a similar nature found elsewhere among the algæ. The two valves or halves of the organism begin a slight process of separation, and as the contents divide into two parts, there are formed within two new halves, one fitting into the larger half of the original cell, and the other forming a new box within the smaller half of the parent cell. These then separate, forming exact counterparts of the mother cell, although one is a trifle smaller than the other. In addition to the above mentioned method of reproduction, the plant also possesses the power to form a large spore, making it more or less resistant to adverse conditions; also, it has been noted that the diatom cell may break up into a number of much smaller spores, each one capable of developing into a new plant.

One organism claimed alike by botanist and zoölogist, but at any rate a troublemaker for the hygienist, is *Uroglena*, belonging to a group known botanically as Syngeneticeæ. This form demands especial attention, for it is probably responsible for more trouble in the water supply than any single representative of the various groups of microscopical plants, excluding of course the pathogenic bacteria.

*Uroglena* is widely distributed over the United States, but is more frequently encountered in New England and in some of our middle western states, Indiana, Ohio, and others. *Uroglena* lives in colonies in appearance resembling a colorless sphere, with a large number of greenish cells embedded in the periphery. Usually much smaller than one-half a millimeter in diameter, the *Uroglena* colony may, however, attain that size. Each individual cell is equipped with a pair of cilia of unequal length, and it is by vibration of these hairlike appendages that the colony is propelled through the water. Each cell of the colony contains in addition to a well-defined nucleus, which appears as a red spot, a single greenish colored body, and several vacuoles. By far the most important content of the cell from a sanitary standpoint and the one that causes the organism to be feared by those responsible for the water supply, is the large number of oil globules. It is the liberation of this oil that causes all of the trouble, namely, the detested fishy-oily odor usually attributed to water containing this form of life. The oil seems to be held in rather loose combination, so that the mechanical breaking of the colony serves to liberate it in sufficient quantity grossly to contaminate the water. The cells of *Uroglena* are, unfortunately, very fragile, and much force is not required to rupture



MINUTE WATER PLANTS THAT CONSTITUTE THE COMMON BRIGHT GREEN SCUM OF OUR PONDS

The many-celled *Spirogyra*, with its beautiful spiral fronds, is shown in 4, at the left, also in 5 after the formation of zygospores, each made by union of the cell contents of adjoining filaments. Other filamentus algæ which have natural odors and may be sources of disturbance in reservoirs of water supply, are (at the left) *Hyalotheca* (1), *Zygnema* (6), *Vaucheria* (7), *Conferva* (8), *Cladophora* (9). The *Volvox* (at the right, 3), consists of a gelatinous sphere often one millimeter in diameter in which the several thousand microscopical cells (black dots in the drawing) are embedded, with their cilia pointing outward. By the beat of this multitude of cilia the sphere, which is lighter than water, is kept rotating and moving about independently like an animal. This form contributes a strong fishy odor and must be filtrated from the water supply. Such forms as *Eudorina* (4) and *Pandorina* (5) also may give a fishy odor to the water.

them and liberate the oil. Usually mere pumping, or even the force of gravity through pipe lines necessary to distribute the water, is enough to cause the disturbance. The exact nature of the oil is not very well understood. It is believed that it is not unlike the so-called essential oils, being nonvolatile at the temperature of boiling water, and seeming to resemble the oils obtained from some of the diatoms and blue-green algæ.

The methods of cell division in *Uroglena* are somewhat peculiar and decidedly interesting. Before dividing, the cell seems to turn in the periphery of the hollow gelatinous sphere, until it is at right angles to the position usually occupied. Then at the end of the cell which originally pointed toward the center of the sphere, there is formed a pair of cilia similar to those at the opposite pole, and the appearance of the characteristic spots of red is then noticed. The cell begins to be sharply constricted, and as it gradually divides, the two halves are drawn back through an angle of about 45 degrees, so that when the cells are finally formed, they occupy a position similar to the one normally assumed by the parent. When a cell colony becomes too large, it divides into individual cells, and these by numerous processes of division soon grow into new spheres. In addition *Uroglena* is also able to form spores, so that it is quite ready to survive periods that would normally lead to its extermination or at any rate seriously handicap its multiplication. Queerly enough, *Uroglena* seems to thrive best during the cold winter months, especially when the surface of the water is frozen. In Europe just the reverse is true, July and August are the months most favorable to its growth, and it disappears altogether at the approach of cold weather. For this reason many seem to think that the European and American types are different species.

Other Syngeneticeæ are concerned with the contamination of water, but usually not to the same extent. *Synura* and *Syncryta* are both accused of having a bad effect, *Synura* being responsible for the offensive "ripe cucumber" odor formerly thought to be caused by fresh-water sponges.

Without doubt *Uvella* should be spoken of, as it is one of our most dreaded forms, and to it has been reputed the cause of an acid in the water which is most disagreeable. It greatly resembles *Synura* and many believe it to be the same organism; it differs, however, from that form in the lack of a separate investing membrane, and by the posterior location of the contractile vacuole. There are also few zoöids contained in the cluster.

Another very bothersome water microörganism, which may be the cause of much annoyance, is the common *Spirogyra*, which has been known to cause thousands of dollars' worth of damage by smothering growing water cress in artificial beds constructed for the winter propagation of this salad plant. When the cress is cut for market, the mutilation leaves the

plant in a much weakened condition, and if *Spirogyra* gets a start, it forms a thick mat over the surface of the water, preventing the growth of the cress, and often killing the entire crop in a given district.

*Anabœna*, one of our most important water contaminants belonging to the order Nematogenæ, surely merits more than a passing mention. George Chandler Whipple, professor of sanitary engineering in Harvard University, in a graphic description of the serious amount of trouble this form may cause, tells how the large Chestnut Hill Reservoir, Boston, was contaminated by *Anabœna*. This blue-green algal form multiplied to such an extent that in the course of a comparatively short time it polluted the entire line of supply of the communities getting their water from the above-mentioned source. In structure and form *Anabœna* much resembles an irregular chain of green beads. The vegetative cells are from five to twelve microns in diameter, depending on the species. It possesses both spores and peculiar dead cells called heterocysts. Being a most abundant producer of obnoxious oils, it causes annoyance in much the same way as does *Uroglena*.

Among other forms giving rise to unpleasant odors and flavors are *Dinobryon*, *Bursaria*, *Peridinium*, and *Glenodinium*. They are not often causes of bother, and are interesting for the most part because of their unusual structure, and like many other microörganisms show the varied forms of plant and animal life which may exist in a given source of water used for domestic purposes.

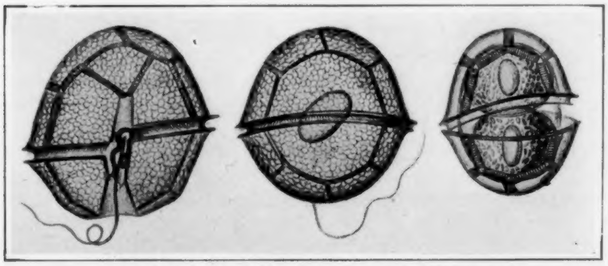
To Dr. G. T. Moore, head of the Department of Botany, Marine Biological Laboratory, Woods Hole, and Mr. K. F. Kellerman, associate chief of the Bureau of Plant Industry, Washington, D. C., two of our most efficient experts on water biology, belongs the credit for suggesting a very good means of controlling these minute pests. The method consists of using small amounts of copper sulphate, a chemical which seems to have a specific toxicity for the lower forms of life. The requisite amount of copper sulphate is placed in a sack of coarse cloth, and drawn slowly back and forth over the surface of the water in the reservoir. Diffusion and the natural circulation of the water serve to mix the chemical and distribute it to all parts necessary. According to Professor Whipple the amount of copper sulphate to be used varies with the following factors: 1, organisms present; 2, temperature of

*EUGLENA*, A MINUTE FREE-SWIMMING ORGANISM WITH A FLEXIBLE WHIPLIKE FLAGELLUM NEAR THE MOUTH

Immense numbers of *Euglena* may collect in a green or reddish scum on quiet water.

*STENTOR*, AN INTERESTING MICRO-ORGANISM WHICH NEVER EXISTS IN SUFFICIENT NUMBERS TO BECOME A PEST

Rapidly vibrating cilia at the top where the mouth is, maintain a current which carries in food particles.

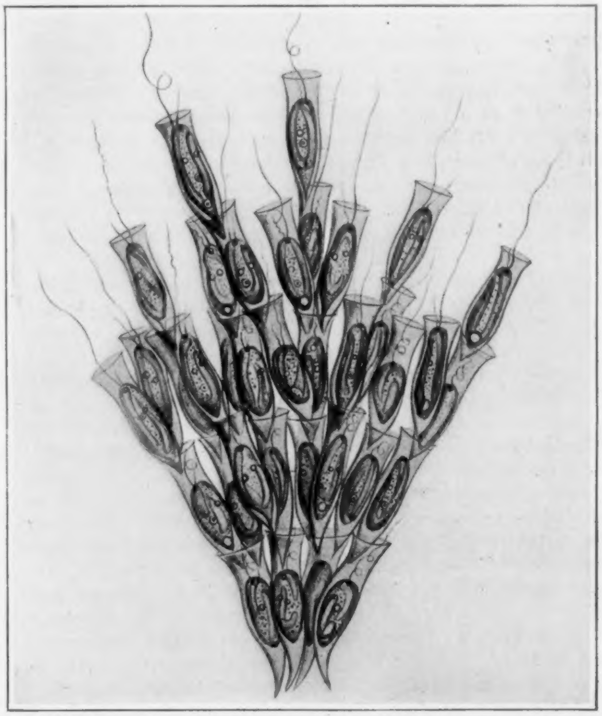


*GLENODINIUM* WHICH GIVES A FISHY ODOR

It is said that *Glenodinium* imparts a fishy odor to water in which it grows, but the species is not common enough to be an important source of trouble. In gelatinous masses on the water it shows phosphorescence.

*PERIDINIUM* WHICH GIVES A "CLAM SHELL" ODOR

*Peridinium* is a consort of the diatoms in the floating life of lakes and reservoirs and especially of the sea. It is not sufficiently abundant to be troublesome in the water supply, but it is said that it produces a fishy odor "like that of clam shells."



COLONY OF *DINOBRYON* WHICH GIVES A FISHY ODOR.

These colonies may be either attached to objects in the water or free-swimming. New colonies are formed and dispersed by spores so that large numbers of the animalcules may be generated within a brief period if conditions are favorable.

the water; 3, the amount of dissolved organic matter; 4, hardness of the water. In the case of the more susceptible organisms such as *Uroglena* and *Anabœna*, dilutions of one part copper sulphate to five to twenty million parts of water is sufficient, while for the more resistant forms such as the diatoms, the amount required to produce a lethal effect on the species may be as great as one part of the chemical to one million parts of water. Fortunately, the organisms giving the greatest trouble are the ones which most easily succumb to the copper sulphate method of treatment.

Objections have been raised against this method, due to the poisonous nature of the substances used as an algæcide. There is little reason to believe that there is much to be feared, however, considering the high dilution of the chemical when it ultimately reaches the consumer, especially when the use of copper sulphate is followed by filtration of the water, for by filtering the copper salt is largely removed. Much of the chemical is bound by the ever-present vegetation, while still another portion is precipitated. The use of the copper sulphate method of treatment is not advised, however, without expert supervision.

Pathogenic bacteria do not make the water unpalatable and thus are often tolerated in a water supply for a long time; not until there has been an alarming increase in the death rate from water-borne infections is their injurious presence brought home forcibly to the general public. With algæ it is different, their presence for only a day or two will cause the water to become offensive to such an extent as to make the general rate of water consumption in the community fall far short of the amount needed for physical well-being. Even when a water supply is palatable in every way, people tend to drink far less than is normally needed. Just stop and consider what a vital substance water is: "Seventy per cent of our body weight is composed of it; it enters into the chemical composition of all of the tissues; it forms the chief ingredient of all fluids of the body and maintains their proper degree of dilution, and thus favors metabolism; by moistening various surfaces of the body, such as mucous and serous membranes, it prevents friction; it furnishes in the blood and lymph a fluid medium by which food may be taken to remote parts of the body and waste material removed, thus promoting rapid tissue changes; it serves as a distributer of body heat; and it regulates the body temperature by the physical process of absorption and evaporation."

One of the most common dietetic faults is neglect to take enough water into the system. It is important, then, to have a pure and wholesome water supply that may be partaken of with enjoyment by all.

# Theory and Practice of Lubrication*

## Increasing the Life and Activity of Lubricating Oils by Means of the "Germ" Process

By Henry M. Wells and James E. Southcombe, M.Sc.

THE considerations which we wish to bring forward in this paper are the results of many years' experience of the problems of lubricating oil and lubrication, studied from a physical and physico-chemical standpoint, assisted by an intimate and daily contact with the lubrication of all types of machinery and prime movers. Our primary object was to elucidate the reason for the obviously superior lubricating efficiency of fatty glycerides over "straight" mineral oils in a large number of practical cases which had come to our notice.

As a corollary to this we had to review the physical principles upon which lubrication depends and to seek an explanation of the peculiar property which has been called "oiliness," "body," etc., by authorities in the past.

It may not be out of place here to review the position of our knowledge of lubricants and lubrication.

Professor C. V. Boys, in his Presidential address to the Physical Society in 1908, crystallized the position very happily in these words:

"It was found that the lubricating property of oil depended on something which at present is unknown. It is not viscosity—animal and vegetable oils lubricate better, *i.e.*, they are more 'slippery' than mineral oils of the same viscosity, and though the oil trade has known how to make good 'slippery' mixtures, no one at present knows what 'oiliness' is, and this is at the present time an important physical quest of the engineer."

Again, Professor J. S. Brame has said that[1] "the property of 'oiliness' was one of the most puzzling of the properties of oils. By some it was regarded as unnecessary to connect it with viscosity directly, since it was possessed in a much greater degree by some fixed oils than by many mineral oils which had practically the same viscosity."

It is necessary to distinguish clearly between two distinct classes of lubricating practice. On the one hand we have the lubrication of fast-moving shafts, etc., supplied with a large excess of oil frequently under pressure, and in this case the frictional values are dependent primarily upon the viscosity of the oil; the mathematical and experimental investigation of these cases have been amply treated by Reynolds, Tower, Lasche, and others. On the other hand we have to deal with slow speeds at high bearing-pressures, frequently with a very limited supply of oil, and it is in these cases that the special property of "oiliness" or "body" is requisite to maintain the film, and it is here that viscosity measurements no longer assist us in the choice of the lubricant.

This view received unanimous support at the recent discussion on lubrication at the Physical Society.

What are the possible physical properties of a liquid which influence its character as a lubricant? They are viscosity, density, capillarity or surface tension, compressibility, and tensile strength. It is true that very little work has been done on compressibility and tensile strength, but from the observations of Worthington and others it would appear doubtful

FIG. 1

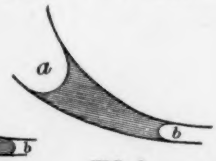


FIG. 2

CAPILLARY ACTION OF MERCURY AS COMPARED WITH OIL

whether they would play a *distinguishing* rôle in the differentiation of oils; and, further, as we shall point out, there is what appears to us an adequate explanation of the nature of oiliness without calling upon these properties.

So far as density is concerned there exists a wide range of petroleum mineral oils possessing specific gravities identical with those of the fatty or fixed oils, hence it is clear that density plays no determining part. Viscosity is, of course, of great significance in the cases of high speed, etc., just referred to.

Now it remained for Ubbelohde to point out that only a liquid which "wets" or "spreads over" the solid can constitute a true lubricant, because in order for the liquid to force itself

*Paper read before the London Section of the Society of Chemical Industry, Feb. 2, 1920. Reprinted from the *Journal of the Society of Chemical Industry*, March 15, 1920.

[1] *J. Inst. Pet. Tech.*, 1918, 4, 219.

into the narrower spaces of higher pressure it is essential on capillary grounds that the said liquid shall "wet" the solid surfaces.

Consider the case of two eccentric glass surfaces which are being forced together with a drop of mercury or oil between them. Now since the mercury (Fig. 1) does not "wet" or spread over the glass, the meniscus in this case will be convex to the liquid, while in the case of the oil (Fig. 2), which wets the surface, the meniscus will be concave. In the case of Fig. 1 (mercury) the tendency on capillary grounds will be for the liquid to gather itself up into a drop and to pull the liquid film in the direction of *a* away from the narrower constricted area of greater pressure at *b*. In the case of oil (Fig. 2) the opposite will be the case. The oil will, owing to its meniscus, tend to be pulled towards *b* or, in other words, will force itself into the narrow spaces.

This is exactly what is required in a lubricant, namely, that it shall penetrate into the narrow spaces between journal and bearing, and from the above considerations one clearly sees that liquids which do *not* "wet" solid surfaces cannot be described as lubricants.

Only those liquids which "wet" a solid surface possess lubricating power in the generally accepted sense.

Although these considerations appeared to indicate the connection between lubrication and capillarity, it will be seen that they only go so far as to enable us to say that mercury is not a lubricant and that oil is a lubricant. This is a conclusion of considerable theoretical interest, but it is not very helpful to the oil technologist who desires to differentiate between different classes of oils.

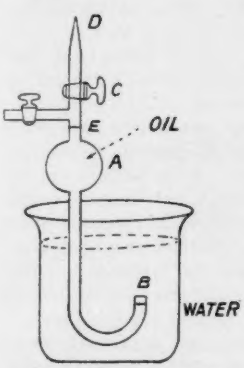



FIG. 3. MEASURING INTERFACIAL TENSION

Accordingly we find that these speculations of Ubbelohde led to no practical result.

On the other hand, certain theoretical considerations had led to the conclusion that the permanence of liquid films depended upon capillary relationships, and in particular that *pure liquids would not form stable films.* These principles had not been applied, however, to the problem of lubrication, and, in fact, they were directly contradicted by prevailing practice in which there was a constant tendency towards greater purity, *i.e.*, in the direction of refining the mineral oils which were used, and in the direction of using acid-free oil as a compounding ingredient.

The generally accepted view was therefore that capillarity was not a deciding factor in connection with the phenomenon of "oiliness," and various standard works contain statements to this effect.

It was under these conditions that we began our experiments. We were at once met by the fact that it was not possible to measure the surface tension between oil and the solid metal bearing, and it is probably on this account that Ubbelohde's speculations remained abortive. The usual "surface tension" is that of oil against air, and we confirmed the results of previous investigators, viz., that the results so obtained, for instance, by observing the rise in a capillary tube, shed no light at all on the question under consideration.

At this point we decided to measure the surface tension of the oil against an immiscible liquid in the hope that this might furnish some criterion of "oiliness." On proceeding to measure this interfacial tension, *i.e.*, the surface tension between oil and water, startling results were at once obtained. The method of experiment was by the drop pipette as follows: The pipette consists of a U-shaped capillary tube provided with a bulb A (Fig. 3) and a ground glass orifice B. The bulb A is filled with oil to the mark E. By means of the capillary D a very slow flow of oil may be obtained at B by opening the stopcock C. The orifice is immersed in a beaker of water, and the number of drops formed by the given volume of oil in A is counted. The surface tension oil-water is inversely proportional to the number of drops.[2]

A series of mineral oils were tested with this instrument, and then a series of animal and vegetable oils and compounded oils.

The following table shows a few results selected from a very large number of trials:

TABLE I

***Table of Interfacial Tension by Drop Numbers of Various Oils Against Water.***

**Mean temperature 70° F.**

| **OIL.** | **No. of drops at constant orifice and head.** | **Tension in arbitrary units.** | |
|---|---|---|---|
| Paraffinum liquidum | 95 | 100 | Mineral oils. |
| 0·905 mineral | 101 | 94 | |
| Solar red mineral | 102 | 95 | |
| Non-viscous neutral | 99 | 93 | |
| Olive | 132 | 72 | Fatty oils. |
| Rape | 138 | 68 | |
| Coconut | 161 | 59 | |
| Lard oil | 128 | 73 | |

A glance at the table shows the surprising fact that *the interfacial tension against water of the vegetable and animal oils is much lower than in the case of a mineral oil.*

What is more, we were struck by the fact that we had here a test which showed a distinct physical difference between mineral and saponifiable oils independent of viscosity, density, etc., and this difference appeared to be in conformity with the lubricating properties of the oils.

It now remained to inquire what was the reason for the difference in tension. After considerable experimentation we proved that the lowering of the interfacial tension against water in the case of fatty oils was *due to their slight content of free fatty acidity.*

The following table shows some of the results:

TABLE II

| OIL. | Free fatty acids, calc. as oleic. | Drop no. | Interfacial tension. |
|---|---|---|---|
| 0·905 mineral | nil | 101 | 100 |
| 98% mineral, 2% com. fatty acids | 1·9 | 125 | 80 |
| 97% mineral, 3% com. fatty acids | 2·8 | 130 | 78 |
| Olive | 2·2 | 125 | 80 |
| Olive | 4·5 | 140 | 72 |
| Rape | 2·5 | 132 | 76 |
| Coconut | 4·1 | 148 | 68 |
| Olive (neutral) | 0·1 | 110 | 92 |
| Rape (neutral) | 0·15 | 108 | 93 |

By removing the free fatty acids from the saponifiable oils the tension rises, and by adding free fatty acids to the mineral oil the tension can be lowered.

Now all commercial animal and vegetable oils contain small quantities of free fatty acids, and even if the utmost care has been taken in refining to remove the acidity, hydrolysis soon sets in and free acids are formed which, in even relatively minute quantity, suffice to lower the surface tension. Table III shows the percentage of free fatty acids in representative samples of animal, vegetable and compounded oils on the market. It is representative of the general glycerides and commercial compounded lubricating oils in daily use on all types of power plant, and we see that fatty acids are always present to a certain extent. From the foregoing it is demonstrable that:

1. Capillary effects (hitherto ignored in lubrication) play a fundamental part.

2. The presence of fatty acids in an oil lowers the surface tension of said oil against water.

3. A neutral glyceride possesses a similar tension to a neutral mineral oil.

4. The addition of a relatively minute amount of a fatty acid to a neutral mineral oil reduces the tension to that of a commercial animal or vegetable oil or compounded lubricating oil.

[2]Donnan, *Zeit., f. Physikl. Chem.* Vol. 31, etc.

Now it remains to inquire how far these results influence the theory and practice of lubrication of solid surfaces. It might be argued that the interface between oil and water is a different thing from the interface between oil and metal, and that the conclusions drawn from the one case are not necessarily applicable to the other. As a matter of fact such similarity in effect is not unknown in other instances, and to obtain more conclusive evidence Professor Lewis has measured the interfacial tension between oil and a liquid metal—mercury. (It should not be forgotten that solid-liquid interfacial tension cannot be measured.) His results are as follows: Pure neutral mineral oil, 100; same mineral oil plus 2 per cent of commercial fatty acid, 89. It is seen that again there is a lowering in the interfacial tension as a result of the addition of the organic acids, and, what is more striking, the relative lowering produced is very much the same as it is in the case of an oil-water interface.

Professor Lewis remarks: "One may conclude therefore with some confidence that the addition of the organic acids will lower the tension at any metal-oil interface."

Again, as already pointed out, the permanency of films is dependent upon a diminished interfacial tension between the oil and the metal in contact therewith. If such a film is broken the possibility of its uniting again to form an unbroken layer depends entirely upon the interfacial tension being low. Any substance which lowers the interfacial tension causes the liquid to spread over a larger area of the solid. It follows therefore that if a substance be added to an oil which brings about a lowering of interfacial tension, such addition will act favorably as far as lubrication is concerned by preventing a rupture of the liquid film and preventing in turn the metals from coming into direct contact.

TABLE III

| | *Acidity (as oleic).* |
|---|---|
| Animal oil, pale | 4·2 to 25·55 |
| ″ ″ brown | 12·02 to 30·32 |
| Castor, firsts | 0·49 to 1·70 |
| ″ seconds | 2·12 to 7·40 |
| Coconut, Cochin | 1·26 to 19·11 |
| Colza, Belgian | 1·97 to 3·22 |
| ″ Stettin | 1·41 to 4·48 |
| Lard, pressed | 0·28 to 0·71 |
| Olive oil, Algerian | 2·52 to 13·72 |
| ″ Gallipoli | 12 to 33·14 |
| Palm oil | 24·68 to 56·05 |
| ″ bleached | 14·1 to 27·49 |
| Rape oil, Black Sea, refined | 1·82 to 4·34 |
| ″ East India | 1·26 to 4·24 |
| Sperm oil, Arctic no. 1 | 0·56 |
| ″ ″ no. 2 | 0·42 to 4·34 |
| ″ Southern | 0·7 to 2·86 |
| Tallow | 1·55 to 43·71 |
| *Standard Brands of Compound Oils on the Market:* | *Acidity (as oleic).* |
| Marine engine oil, D | 1·3% |
| ″ ″ ″ O | 5·15% |
| ″ ″ ″ T | 4·5% |
| Motor oil, X | 0·26% |
| ″ Y | 0·5% |
| ″ Z | 2.5% |
| Compound steam cylinder | 0·4% |
| Medium gas and oil engine oil | 0·25% |
| ″ ″ ″ ″ | 0·39% |
| Light gas and oil engine oil | 1·6% |
| ″ ″ ″ ″ | 1·3% |
| Heavy gas engine oil | 1·28% |
| ″ ″ | 2·5% |
| Oil engine oil | 0·7% |

The capacity for spreading may be considered as partly physical and partly chemical, due presumably to residual valency. The effect is to render the transition layer between the liquid and solid less abrupt. This diminution in abruptness can be brought about by chemical action direct or indirect across the transition layer or by the solubility of some third substance in both phases.

H. S. Allen has recently pointed out that on Langmuir's view oiliness depends on the chemical forces called into play between the active part of the oil molecule and the solid surfaces of the bearing.

Now it is obvious that there is a tendency for chemical activity between the metallic surfaces of bearing and journal and an oil containing free fatty acidity, while such tendencies are less pronounced in the case of a neutral mineral oil. Such a tendency would render the transition between oil and solid surfaces less abrupt, would manifest itself by reduced interfacial tension, and would result in better spreading and consequent increased efficiency in lubrication.

There is little doubt in our minds that the physical rationale of the property of "oiliness" is now explained, and we have confined ourselves so far to a statement of the physico-chemical experiments which we have made and to the development of the physical theory.

Conclusive as it appears to us we have proceeded to test and verify the conclusions by direct friction measurements, and finally by the only real touchstone, namely, the test of experience in a long series of practical trials on all types of machinery and prime movers of the very largest sizes.

We will proceed to consider some of the results in detail.

First we beg to tender our thanks to Mr. L. Archbutt for the frictional test made by him, which he has communicated to the Physical Society at its recent discussion on Lubrication.

Archbutt has made a series of determinations of the frictional coefficient on a Thurston machine under a load of 270 lb. per sq. in. at the very slow speed of 7 ft. per minute.

His results are as follows: Pure mineral oil, 0.0047; do. plus 1 per cent rape oil fatty acids, 0.0033. He finds that 1 per cent of free fatty acids lowers the coefficient as much as does 60 per cent of pure rape oil (acid-free).

These results have been confirmed by us on an independent machine, as we shall show later.

He has also shown, however, that pure neutral rape oil also possesses a lower coefficient than mineral, and concludes that "these results would suggest that the oiliness or lubricating efficiency of the unsaturated molecules of rape oil was really as great as that of the free fatty acid molecules, but that the acid molecules were much more active in their influence on the hydrocarbon molecules of the mineral oil."

These results, which show that 1 per cent of free fatty acids of rape oil added to a mineral oil are as effective in reducing the value of the frictional coefficient as is the addition to the mineral oil of 60 per cent of neutral rape, are striking confirmation of the above described principles, and coming from a totally independent and unbiased experimenter afford great support to our contention that it is not the glyceride but free fatty acids in a compounded oil which improves its lubricating value.

Through the courtesy of one of the largest engineering firms in the country we have been enabled to make a series of measurements in a large friction testing machine, the results of which we here reproduce: The test journal of the machine—which is of the Thurston type—is 3.8 in. diameter, giving approximately one foot peripheral per revolution. The length of the journal is 6½ in., and in all our experiments the load was 200 lb. per sq. in. The machine is provided with a revolution counter and a drum upon which the reading of the arc is automatically traced. The driving motor was operated by a variable speed controller, and all care was taken to ensure steady and constant speeds. The journal and bearing were thoroughly cleaned before each test by washing with tolulol, and finally rotated against velvet pads to remove all superficial dust and moisture. The experimental temperature was kept between 60 and 64 deg. fahr.

The values of the frictional coefficients calculated from the curves obtained directly from the machine are given below.

By way of illustrating our point, four oils were chosen of identical viscosity and density but differing in composition thus:

These results afford great support to the views expressed above, and, coupled with our experience in practical lubrication, about to be mentioned, confirm our explanation of the property of oiliness and open out a new and invaluable field in the manufacture of lubricating oil.

We should here mention that this principle of making lubricating oils by adding to mineral oils small quantities of fatty acids or substances which lower the interfacial tension has been accepted by the Patent Offices in all civilized countries.

We should add a word here with regard to the possibilities of corrosion.

As will be observed from the table below, all compounded oils which have been and are in daily use for years contain notable amounts of free fatty acidity, yet one rarely hears of any active corrosion.

In our case we add only very minute amounts of fatty acids, and the quantity is strictly limited and controllable. But where fatty glycerides are employed the amount of acidity which can form is potentially very large because hydrolysis is constant, giving rise to the production of free acids.

During recent years a great deal of attention has been devoted to the study of the colloidal characters of the fatty acids, and it has been shown that while the lower members of the fatty acid group possess relatively little colloidal character, the higher members are highly colloidal in character. Donnan and Potts have shown that there is a gradation in these properties as one ascends the scale, lauric acid occupying a sort of intermediate position. Also the lower members of the series possess strong acid characteristics, while the higher members are very weakly acid. Now the fatty acids which occur in commercial oils are never pure chemical individuals, but are mixtures in varying proportions of a considerable number of fatty acids. Coconut oil, for example, is characterized by containing appreciable percentages of the lower members of the series, while rape oil rarely contains anything but the higher members.

It is only to be expected, therefore, that the behavior of these oils will differ in accordance with the fatty acid groups which predominate in them, and it is possible to reproduce the capillary properties of any particular animal or vegetable oil by adding suitably chosen fatty acids to mineral oil.

Consider the case of a steam engine using saturated steam, where there is a tendency for condensation of water to occur in the cylinder and valves. It follows in such a case that the presence of a substance in the oil which lowers the surface tension against water will in such circumstances assist in the formation of oil films by enabling the oil to spread more readily or by overcoming the tendency of the water to wash the oil film off.

There is a certain type of lubricating phenomena to be considered where the oil is brought into contact with water and it is desirable that the oil shall either separate itself rapidly from the water (de-emulsification) or, conversely, that it shall mix or emulsify with the water.

Now the phenomenon of emulsification is dependent upon the colloidal properties of the oil, while de-emulsification is brought about by a greater concentration of hydrogen ions. Consequently one would expect the oil containing the higher members of the fatty acid group to possess an emulsifying tendency, while one containing the lower members will possess a de-emulsifying tendency. This is a feature which we have tested by shaking oils and water at various temperatures for long periods of time, and to a great extent we have been able to substantiate this view as the result of experiments.

After the soundness of our theory was clearly demonstrated in the laboratory it remained for us to put it to the touch of actual practice to prove its real value in the world of engineering.

Not a single failure has occurred in practice of an oil or an oil "essence" made on the "germ process" as a reliable lubricating oil when used for the purpose for which it was supplied. The meaning of "oil essence" is explained later.

We use the expression "germ process" to describe the oil made by using one or more fatty or other acids with one or more mineral oils, because the world has been taught for generations to look upon acid as the deadliest enemy to good and safe lubrication. As the *germ* is the first principle of organic life, by analogy we call a suitable acid when dissolved in mineral oil the "germ," which gives to mineral oil its life and activity as a more perfect "instrument of lubrication."

We do not claim that a "germ process" oil is better for all conditions of lubrication, but for many purposes where lubrication depends upon the oil alone and not upon any mechanical means, such as pressure, to maintain a continuous film.

We have proved to our entire satisfaction that the addition of fatty oils to mineral oils for many purposes of lubrication is unnecessary and a waste of valuable material, and that for such purposes oils combining small percentages of suitable free fatty acid or acids with suitable mineral oils are at least equal to oils compounded on the old formulæ for those purposes. Therefore many of the old formulæ and specifications for compound oils are obsolete. Where the expression "compounded oils" is used, it indicates such old formula oils. Also, "mineral *oil*" indicates in many cases one or more than one mineral lubricating oil. "Fatty oil" includes tallow and other "fats" used for lubrication.

TABLE IV

| Oil. | Viscosity at 60° F. Seconds Redwood. | Sp. gr., at 60° F. | Total acidity, calc. as oleic acid. | Mean temp. of expts. | Peripheral speed in feet per minute. | Quantity of oil used for test. | Arc. | Coefficient of friction. |
|---|---|---|---|---|---|---|---|---|
| A. Pure mineral | 973 | 0·909 | nil | 62 | 11 | 5 c.c. | 40 | 0·0084 |
| B. 97% Pure mineral, 1% Pale cylinder *, 2% Com. fatty acids | 973 | 0·909 | 1·9% | 62 | 11 | 5 c.c. | 25 | 0·0052 |
| C. 80% Mineral, 20% Olive | 980 | 0·908 | 0·3% | 63 | 11 | 5 c.c. | 40 | 0·0084 |
| D. 40% Mineral, 60% Olive | 970 | 0·907 | 0·9% | 64 | 11 | 5 c.c. | 35 | 0·0073 |

* Added to keep the viscosity constant.

*Gas Engines.*—It has always been considered that the addition of coconut oil to a mineral oil gave the best results. Refined rape oil or other fatty oil was also used in conjunction with coconut oil to the extent of about 5 per cent of each; that is, about 10 per cent of fatty oil, 90 per cent mineral oil. Especially on large horizontal units such a compounded oil was deemed essential. For smaller units smaller proportions down to 5 per cent total fatty oil to 95 per cent mineral oil; though some small units apparently required heavily compounded oils.

So far as our business is concerned, "germ process" oils have entirely displaced such compounded oils for horizontal and vertical engines up to the largest units of both types.

Some gas engines run on "straight" mineral oil with good results, but roughly it can be claimed that ten units run on "germ process" oil to one on straight mineral.

*Oil engines.*—Compounded oils, and for some types "straight" fatty oils such as olive oil, have been considered essential for oil engines. For several types it was thought necessary to use a compound of *one-third refined rape oil* to two-thirds mineral oil. That oil has been entirely superseded by an oil with a slightly higher percentage of fatty acid than the average "germ process" oil for oil engines, but not over the maximum considered safe in practice. For other oil engines, land and marine, for which compounded oils were thought necessary, their place has been taken by oils made from one or more fatty acids with mineral oils of suitable quality.

The quality of the mineral oil with which the acid is blended is a very important factor in lubrication. The germ process gives to a mineral oil of fair merit that property lacking for some purposes; while it increases the lubricating value of a

"good" oil, making it still better for many purposes. In both cases they become more economical.

*Steam cylinder lubrication.*—It is almost universally considered that for "perfect" lubrication of steam cylinders with certain types of valve gear (as one example, "Corliss"), and for engines working under certain conditions—say with much condensation in the cylinder—a compounded oil is essential.

"Germ process" oil incorporated in very small proportion with the correct mineral cylinder oil gives equally good results on engines with Corliss valves up to over 3,000 hp. working at 160—170 lb. per square inch pressure, superheated 480—500 deg. fahr.; on horizontal engines with Corliss valves up to 750 hp. up to 160 lb. pressure without superheat. Various mineral cylinder oil bases to correct "germs" in different but small proportions give good lubrication on vertical and horizontal engines of many types, sizes and pressures.

*Oils for steam turbines, crank cases of vertical steam, gas, and oil engines.*—The property most essential in oil for steam turbines, namely, non-emulsification, is the one which largely governs successful crank-case lubrication in vertical engines. In such cases and in turbines water from condensed steam or from the cooling system falls into the crank-case and gets "churned" as it is pumped round with the lubricating oil. For these conditions one has to know something about impurities in the water, as the water is the deciding factor. The "germ" must be carefully adapted to the water as well as to the oil, and the oil to the mechanism. Where one oil is used for cylinder and crank-case lubrication (say, of gas and oil engines) the "germs" can be balanced to give what for convenience can be described in a general way as a positive effect in the cylinder where extra capillarity is required, and a negative effect in the crank-case where emulsifying is undesirable, and where the engine is steam, of the splash lubrication type, to give just enough emulsion and no more for its intended work in the cylinder, also in the crank-case, where it must emulsify. The germs, for they are many, can be so adapted when one thoroughly apprehends their properties, to give perfect lubrication in all such cases.

*Marine steam engine bearings—open type.*—For a good heavy marine engine oil it has always been considered necessary, and is so today, to use from 10 to 25 per cent thickened or blown oil—as a rule, thickened rape oil. This gives great viscosity, also very good "lathering" properties to the oil.

The standard specification for marine bearing oil for one of our semi-Government departments is a compound of about 20 per cent of "fatty oil"; but the total fatty acid content must not exceed 1 per cent. This has now been successfully replaced by "germ-process" marine-engine oil.

On February 5, 1918, we filed our patent[3] for oils made on this new process, and immediately its "publication or communication" was prohibited by the Admiralty, who carried out trials over many months on about fifteen ships of the mercantile marine, including a fair proportion of liners. The result was quite satisfactory.

At this stage we decided to supply the fatty acids in a form, which we term "essence," mixed with mineral oil and which can be conveniently used on board ship; about 2½ per cent is added to the mineral oil as required. The result justified all claims. The consumption of mineral oil was considerably reduced, hot bearings were cooled, and thrust blocks were kept cool by the addition to mineral oil of suitable "germs." The trials were a complete success.

We think it desirable to say that it may not be advisable for oil users in general to buy fatty acids, to mix them in their oil and imagine all advantages mentioned will accrue. Suitable acids must be chosen for the purpose.

*Conclusions.*—We have shown (1) that fatty compounded oils are unnecessary for many purposes of lubrication; (2) that fatty oils are not essential for such work; (3) that fatty acids can completely displace fatty oils for those purposes.

[3]Eng. Pat. 130,677; see *J. Soc. Chem. Ind.*, 1919, 674.

## PIGMENTS OF FLOWERING PLANTS.

IN the bulletin series of the University of Wisconsin a thesis on the pigments of flowering plants by Miss Nellie A. Wakeman appeared a few years ago. In view of our present-day interest in dye-stuffs and in the work of the tiny laboratories in plant cells, it seems that attention may be recalled to Miss Wakeman's work.

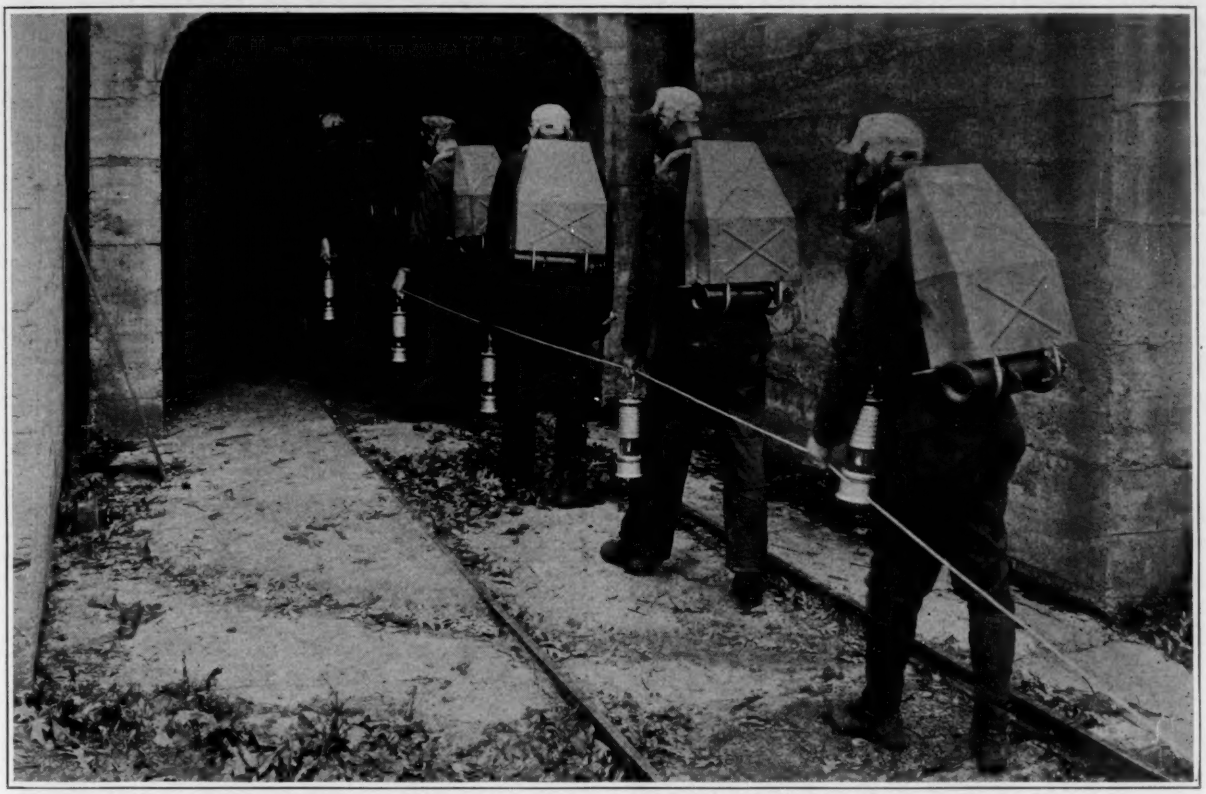
As the author states, it is desirable to remind the uninitiated that color is the response of sensation to the stimulus of light, which proceeds from the colored substance either by transmission or reflection, and that color does not inhere in the colored substance itself. Various dyes and pigments possess their tints because of a process known as selective absorption, in which each pigment absorbs certain definite colors from white light and transmits or reflects only those which it does not absorb. A transparent object appears to be the color of the light which it transmits, while of course an opaque object is judged by the color which it reflects. Thus, a black object absorbs all the radiations of white light, while a red object absorbs all but the red. If none is absorbed the object is white, and if all are transmitted, the object is colorless. Again, if light of only one color is absorbed, its complementary color will alone be visible and obviously if two complementary colors alone are absorbed, the object will be relatively colorless.

According to Witt, color in the pigment of flowering plants is due to the presence of a chromophore group in the molecule. Such a substance, though generally colored, is not a dye-stuff and was given the name chromogen by Witt. It only becomes a dye upon the introduction of a salt, forming an auxochrome group. Some of the earlier investigators found that changes in color in general are the results of changes in selective absorption in the regions of the visible spectrum and Scheutze stated that a change of absorption from violet toward red usually causes changes in color from greenish yellow, through yellow, orange, red, violet, bluish violet, blue, green, etc. Passing through the colors in this direction he designated as deepening or lowering the tint, and in the opposite direction raising the tint. Definite atoms and atomic groups by their entrance into the molecule cause a characteristic deepening or raising of the tint for compounds of the same chromophore in the same solvent. Hydro-carbon radicals always deepen the tint and consequently in homologous series the shade always deepens as the molecular weight increases. The addition of hydrogen results in raising the tint. We find evidence from this, therefore, that the color of a substance is not conditioned by the presence of a definite group but by the entire structure of the molecule.

In the work on the thesis in question, which was begun several years ago, the study at times was purely chemical without any bio-chemical significance, and at times assumed the character of a study of the extracted pigments and the examination of the products obtained. It has been found that no adequate knowledge of plant pigments can be gained by simply studying the pigments, and that each pigment should be considered in relation to other colored substances in the same and related plants, as well as to the non-colored substances. A close relationship has often been found between the colored and uncolored constituents of a plant or plant family.

Organic pigment molecules have been found to be unsaturated. The highest degree of saturation in a pigment molecule is referable to $C_nH_{2n-4}$ and visible color exists in the substance of this degree of saturation only when the quinone group is present. The quinone grouping is one of the best known and most reliable of the chromophorous groups. The largest number of the plant pigments are referable to hydrocarbons of the degree of saturation $C_nH_{2n-14}$ and $C_nH_{2n-16}$ although occasionally compounds up to $C_nH_{2n-34}$ have been isolated.

In the study of the influence of the chromophorous groups upon the production of color, the definite conclusion has been reached that color appears as a function of the entire molecule, not of groups or elements.



CREW OF MEN FITTED WITH OXYGEN BREATHING APPARATUS ENTERING A MINE WITH A LIFE LINE

# Peace-Time Uses of the Gas Mask*

## Recent Work of the Industrial Gas Laboratory of the U. S. Bureau of Mines

By S. H. Katz

Assistant Physical Chemist of the U. S. Bureau of Mines

TO aid its work in the promotion of safety and efficiency in the mineral industries, the Bureau of Mines, at its Pittsburgh Station, maintains a laboratory for the investigation of gases and the dissemination of information about them. Problems relating to the protection of workers who may be exposed to gases are submitted to this laboratory for solution as are also gas problems which aim toward better utilization of mineral resources.

Gases are tenuous substances compared to solids and liquids so their study requires apparatus and technique altogether different from those employed for the grosser matter. Gases must be kept confined at all times; if they once escape from their container into room air they have forever won their freedom. Some of the apparatus at the gas laboratory presents the appearance of a maze of glass tubes, vessels, and accessories in which individual gases pass about, mix with each other, act chemically and physically upon substances put in their path, exert pressure on their confining walls, or exhibit a reluctance to leave a vacuum behind when a pump extracts them. All these actions are quite invisible to the eye of a casual observer, but they are measured with precision and accurately controlled by the chemist who watches the indicators and operates the instruments before him.

Most of the recent work of this laboratory has pertained to gas masks. Before the world war the Bureau of Mines maintained crews of men trained in the use of self-contained oxygen breathing apparatus, which carry enough exygen compressed into metal bottles to maintain a man for half an hour or more. The bottled oxygen enabled wearers of the apparatus to penetrate mines filled with deadly gases from fires of explosions, for the purpose of rescuing entombed miners and again re-establishing living conditions in the mine. With the advent of the war the experience of these men was used by the Government in developing the Army type of gas mask as used by our soldiers. Gas masks differ from oxygen breathing apparatus in that masks serve only as filters for removing comparatively small amounts of noxious gases from air; they presuppose that the wearers are surrounded by atmospheric oxygen in the necessary abundance to support life. This condition is the usual one above ground, but in mines with their limited content of air and in small, tightly closed spaces above ground the oxygen may be depleted, especially by fires. Hence, each type of respiratory apparatus has its own particular field of usefulness. The Bureau of Mines is now interested in adapting the gas mask to serve in the industries where they are finding wide application. The SCIENTIFIC AMERICAN has previously told of the numerous uses made of the gas masks.[1] Their effectiveness in civil life may be shown by these incidents.

A manufacturer had installed a large storage house containing wooden bins which were rather deep and narrow. To paint the bins inside and out it was necessary to use an air spray "brush." The painters working in the openings of the bins

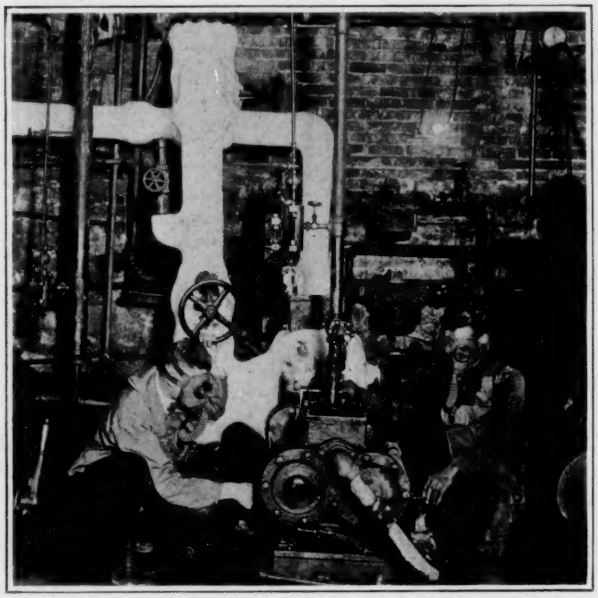
*Published with the permission of the Director, U. S. Bureau of Mines.

[1]The gas mask in industry. The Bureau of Mines tells what it will do and what it will not do; *Scientific American*, Vol. 121, Oct. 25, 1919, pp. 421, 426-9.

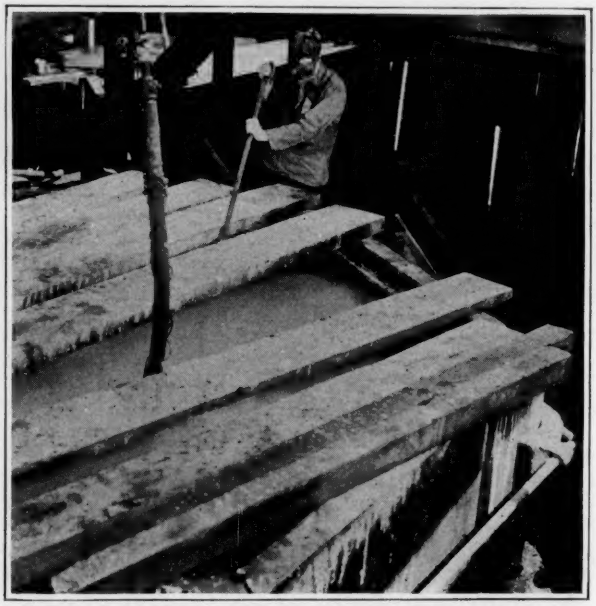
necessarily inhaled the turpentine, paint vapors and droplets of floating paint. After a few days they were made sick; one was confined under the care of a physician for weeks. Thereafter gas masks were provided and the job was completed by men who worked on it for months with no further ill effects.

At a fire in a large paper storage house in Pittsburgh, ten masks were available for the firemen. The men who wore the masks worked in the fire area intermittently but for hours without ill effects. Firemen without masks would enter and work for five minutes, then it was impossible to remain longer. After a rest in open air they would return for another five minutes, when some would be overcome and some blinded by the smoke. Eighteen were sent to the hospital after such experience. In this particular fire there was plenty of oxygen and no carbon monoxide in the smoke, hence the gas mask gave good protection.

A man who wears a gas mask into poisoned air entrusts his safety, perhaps his life to the action of the mask. To promote the production of safe gas masks a schedule[2] of tests and requirements necessary to secure the Bureau's approval has been established. Masks submitted in accordance with the provisions of the schedule and which meet its test requirements are listed and announced as approved by the Bureau. An approved ammonia gas mask of commercial production is illustrated in the photograph above.



GAS MASK WORN AS A PROTECTION FROM ACID FUMES



AMMONIA GAS MASK APPROVED BY THE BUREAU OF MINES

The greatest care is exercised by the mine rescue men of the Bureau to maintain their oxygen breathing apparatus in perfect condition and to avoid overstepping the bounds of safety which the apparatus imposes. In spite of such care some unforeseen accidents have occurred as was recently the case resulting in the death of Jas. S. Cunningham, foreman miner of the Bureau of Mines. Cunningham went into a storage tank at the Sinclair Refining Co., Trinidad, Colorado, to make a pipe connection; he wore a half hour oxygen breathing apparatus because about seven inches of gasoline lay in the bottom of the tank and the air was charged with the vapors. It was shortly noticed by observers that Cunningham was in distress. He came to the ladder to ascend but toppled into the liquid gasoline. When removed from the tank he was dead. The question of the cause of the regrettable accident was sought and finally narrowed itself down to possible permeability to gasoline vapors of the rubberized fabric of the breathing bag on the apparatus. An investigation of such permeability, undertaken at the industrial gas laboratory, showed that the bags of rubberized fabric were exceedingly permeable to gasoline vapors. In one test a breathing bag was surrounded by an atmosphere containing 36 per cent of gasoline vapor. For nine minutes no gasoline was detected by the man breathing the oxygen, then it seemed suddenly to come through the bag and an analysis showed 1.13 per cent of gasoline vapor in the oxygen. After breathing this for three minutes the observer could endure no longer; he found it necessary to support himself with his hands in order to stand and objects were swimming before his eyes. Analysis now showed 2.22 per cent of gasoline vapor. Three minutes later there were 2.60 per cent of gasoline vapor. An attempt was made by another person to breathe this mixture but only 10 or 12 breaths were taken before he began to feel dizzy.

Regardless of whether or not the unfortunate accident was due to permeability of the breathing bag to gasoline vapors, the experiments prove that more impermeable materials are needed for oxygen breathing apparatus, heavier rubber or a different material. Further experiments are in progress from the results of which specifications for breathing bags, impermeable to gasoline and other vapors and gases will be drawn.

At the mines of the Butte and Superior Mining Company, Butte, Montana, the idea was conceived of putting an odorous substance in the intake of an air compressor to force the odor through the air pipes into all parts of a mine. The odor when noticed by miners would serve as a warning to leave the mine when danger arose. It was found that only a few minutes were needed for the very disagreeable odor of valeric acid to pass with the compressed air to all parts of the mine. Mining Engineers of the Bureau of Mines became interested in this method of warning by odors and at their suggestion an investigation of stenches for use as mine warnings was undertaken at the industrial gas laboratory. Tests were made on twenty-four different stenches and odors with an apparatus devised for smelling the intensities of odors of chemicals at different concentrations in air.[3] Five different degrees of intensity were adopted, designated as (1) detectable, (2) faint, (3) quite noticeable, (3) strong, (4) very strong. The

[2]Schedule 14, Procedure for establishing a list of permissible gas masks, fees, character of tests, and conditions under which gas masks will be tested. Bureau of Mines, 1919, 13 pp.

[3]Allison, V. C. and Katz, S. H., An investigation of stenches and odors for industrial purposes: *Jour. Ind. Eng. Chem.*, Vol. 11, 1919, pp. 336-8.

intensity of odor at any concentration as measured, of course, depended on the sensibility and judgment of the operator but the method proved quite satisfactory. Carbon tetrachloride, chloroform and ether had the least odor, probably due to their anesthetizing action on the olefactory nerves. Butyl mercaptan, ethyl mercaptan, amyl acetate and butyric acid proved best for mine warnings after actual tests in mines. The installations needed to inject the stenches into mines through the compressed air lines are cheap and easily installed. Some are now in place at large metal mines. They have been tested experimentally but so far have not been used in a necessary warning. When the information on this method of warning is more generally imparted the number of mines equipped to use it will undoubtedly increase.

GAS MASK WORN BY LOCOMOTIVE ENGINEER TO PROTECT FROM SMOKE IN RAILROAD TUNNELS OF WEST VIRGINIA

Dusts can hardly be classed as gases but since very finely divided dust particles carried by air can be investigated in apparatus somewhat like gases, some problems on dusts have been studied at the industrial gas laboratory. Dusty air has been the cause of much pulmonary trouble to some miners, metal workers and others. Different kinds of dusts vary greatly in their physiological action. Silica dust, in mines where it occurs, is most injurious. Conditions in the United States are not so bad as abroad, notably South Africa, where a miner working at drilling in some mines could hope to live but a short span of years. The dustiness of the air of mines has been investigated principally by means of the so-called "sugar tube," consisting of a glass tube containing a screen to support a column of granulated sugar. The sampler drew a measured amount of the air through a sugar tube by means of a foot pump calibrated to take a uniform volume of air per stroke. As the air filtered through the sugar granules, dust was left there. After a sufficient amount of air had been drawn, the tube was stoppered and sent to a chemical laboratory for determination of the dust content by a chemist. The sugar was dissolved in distilled water and made up to a definite volume. A very small portion of this solution was then examined under a microscope and the number of dust particles in the portion were counted. The solution was then filtered through ashless filter paper, the paper with its dust incinerated and the non-combustible dust weighed. From the data obtained by the chemist and sampler the dustiness at the mine was finally expressed as numbers of dust particles and weight of dust per cubic foot of the air.

Recently a new series of investigations of mine air dustiness was undertaken by the Bureau of Mines coöperating with the United States Public Health Service. The question arose as to the efficiency of the sugar tube filters in retaining

DETERMINING THE PERMEABILITY OF GASES AND VAPORS THROUGH RUBBERIZED FABRICS

the dust of the air passed through them, and its solution was requested of the industrial gas laboratory. A method of testing gas filters had been devised in the Chemical Warfare Service of the U. S. Army;[4] this was applied to the sugar tubes. Briefly it consists of passing tobacco smoke through the filter and comparing the incoming with the outgoing smoke. Tobacco smoke particles are very small and uniform in size, one hundred thousand placed side by side are needed to make an inch, so the smoke forms an excellent medium for testing sugar filters. By diluting a portion of the smoke coming to the filters with a measured amount of pure air until it matches the outgoing smoke the measure of the filter effectiveness is obtained. It was found that the sugar tubes allowed fully half of the air suspended particles to pass through them but when pulverized sugar was used instead of granulated nearly all of the particles would be caught.

In the investigations now proceeding in the mines the granulated sugar is still in use because it is desired to make the present data correspond to that which preceded; but the pulverized sugar filters will undoubtedly be used in following investigations.

Many other gas problems of varied nature have recently been presented to this industrial gas laboratory for solution, such as developing simple tests for detecting the presence of poisonous gases in air, determining the quantities and kinds of poisonous gases generated in some fires, the feasibility of applying stenches to some city fuel gas supplies such as blue water gas and natural gas. The odor of the stench in the gas would warn persons of its presence should it escape from leaks in the pipes and so serve to prevent asphyxiations and explosions which many times wreck buildings, and it would help to overcome a considerable loss of gas that occurs in the distribution.

Altogether these problems seem to put gases in much the same category as fire—when allowed to work their way unhindered they may become the master of man—kept in their proper place and controlled they are a most useful of servants.

[4]Fieldner, A. C., Oberfell, G. G., Teague, M. C., and Lawrence, J. N., Methods of testing gas masks and absorbents. *Jour. Ind. Eng. Chem.*, Vol. 11, 1919, pp. 519-540.

# A New Cadmium-Vapor Arc Lamp*

## Alloying Cadmium with Gallium to Produce a Lamp Giving a Monochromatic Red Light

By Frederick Bates

Physicist, Bureau of Standards

THE necessity of increasing the intensity as well as the number of monochromatic-light sources has been emphasized frequently during the past few years. Unfortunately, little has been accomplished toward attaining this objective. In 1906 the writer[1] directed attention to the importance of this subject and suggested that the so-called yellow-green line ($\lambda$=5461 A) of incandescent mercury vapor be adopted as the source for standardization purposes in polarimetric work. The quartz-mercury vapor lamp was a great advance in that it provided not only the yellow-green line, but several additional lines of lesser intensity. The best available methods of optical purification are such that a monochromatic source is of little value unless the line is so sufficiently removed from its immediate neighbors that nearly complete separation by spectrum filtration is possible. If sufficient monochromatic light to satisfy modern practical and research needs is to be obtained from any such source, it is necessary to use a relatively wide slit, with a consequent probable inclusion of other wave lengths in the immediate vicinity of the one desired.

When the most intense of all known light sources—namely, the direct radiation of the sun—is utilized, the necessary slit width, while less than that for any other known source, must still be such as to include a relatively large number of wave lengths. The effective wave length, or so-called optical center of gravity of such a group of waves, can be considered as a monochromatic light source in only a very restricted sense and finds effective application in but few fields of work. It is especially unsuited to the study of phenomena which change rapidly with a change of wave length. The necessity of obtaining additional intense-light sources is consequently imperative.

Among the possible sources which have been suggested is that of the rotating arc with cadmium-silver alloy electrodes. This source gives a number of fairly intense lines sufficiently isolated from each other and fairly well distributed throughout the spectrum. The writer has carried out many experiments with this source, using an improved rotating arc. It was found impossible to maintain an arc sufficiently free from flicker to give satisfactory results.

Another possible source experimented with is the quartz-cadmium vapor arc lamp, described by Lowry and Abram.[2] This lamp is always unsatisfactory, owing to two defects. It is necessary to have it permanently connected to an air pump and to immerse the electrodes in water. If the cadmium in a vapor lamp is sufficiently pure, the adhesion between the cadmium and the quartz results in the destruction of the lamp upon the solidification of the cadmium. An improved form of lamp has been brought out by Sand.[3] In this type the tendency of the cadmium to adhere to the quartz is stated to be lessened by introducing into the lamp a small amount of zirconia in the form of a fine powder. The cadmium is placed in a side tube connected to the pump and to the body of the lamp by a tube constricted to three capillaries for the purpose of filtering the metal. Additional filtering may be obtained by introducing a roll of iron gauze. Extensive experiments by the writer with this type of lamp have demonstrated that it is impracticable if a pure cadmium spectrum is desired. The method of filtering suggested is inadequate. The impurities introduced into the lamp by this method of filling undoubtedly have a tendency to prevent breakage, but effectively prevent obtaining a relatively pure, intense cadmium spectrum. In order to eliminate all oxide and other impurities from the cadmium used in filling, it is necessary carefully to distill the cadmium into the body of the lamp. Upon allowing the lamp to cool, adhesion between the quartz and the metal takes place in spite of the presence of the zirconia. If the lamp does not crack upon the first solidification of the cadmium, thin sections of the quartz are peeled from the walls by the contracting metal. Upon cooling a second time the lamp invariably cracks.

Numerous experiments of varied character failed to overcome the continued breakage of the Sand lamp. Among the filling mixtures tried was a cadmium-mercury alloy. The percentages of the constituents were varied over a wide range. The introduction of the mercury was very effective in preventing the cracking of the lamp, as the alloy formed was so soft that no appreciable adhesion between it and the quartz resulted. However, it was found impossible to obtain a brilliant cadmium spectrum under any circumstances. The vapor pressure of the mercury was so much higher than that of the cadmium that the electric energy was carried almost entirely by the mercury, and the usual mercury spectrum resulted.

In view of the preceding facts, it was evident that a ser-

*Scientific Papers of the Bureau of Standards No. 371.

[1]B. S. Bulletin, 2, p. 239 (1906).

[2]Trans. Faraday Soc., 10, p. 103; 1914.

[3]Proc. Phys. Soc., London, 28, p. 94; 1915-16.

viceable, brilliant, cadmium-vapor lamp might be obtained by alloying the cadmium with a suitable element of lower vapor pressure. Through the courtesy of Dr. W. F. Hillebrand, a quantity of the little-known element gallium was obtained. The material was in a very impure condition, containing approximately 10 per cent indium. The freezing point was below 22°C., at which temperature it was a liquid with a viscosity less than that of mercury. A study of the impure material was made by Dr. G. E. F. Lundell, who succeeded in obtaining the gallium in a relatively pure condition.

Crude gallium was dissolved in aqua regia, treated with sulphuric acid, and fumed to remove nitric acid. After dilution, small amounts of lead sulphate were filtered off. The solution was then diluted, treated with hydrogen sulphide, and filtered to remove the hydrogen-sulphide group of elements. The filtrate was boiled to expel hydrogen sulphide and treated with ammonium hydroxide. The precipitate was filtered off, dissolved, and reprecipitated three times to free

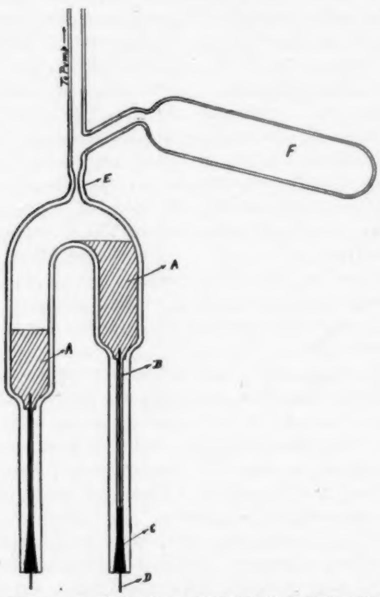



FIG. 1. CROSS SECTION OF CADMIUM LAMP WITH TUBE FOR DISTILLING AMALGAM INTO THE LAMP

it from zinc. The final separation from indium was based on the solubility of gallium hydroxide in a solution of sodium hydroxide and the insolubility of indium hydroxide in that reagent. The sodium hydroxide separation was carried through three times. The position of gallium was finally carried out by electrolysis of the alkaline solution, as recommended by Uhler and Browning.[4]

The purified gallium had a freezing point of approximately 30°C. This surprising fact has since been verified by the careful work of Richards[5] who has definitely fixed this temperature at 30.8°C. Little is known regarding the boiling point of this element. The few experiments which have been made are in agreement that it is above 1500°C. This property should make gallium an ideal substance for the purpose in hand, provided it would alloy with cadmium. The first experiment demonstrated that it unites with cadmium with the utmost ease. In fact; the addition of a few drops to 10 or 15 cc. of cadmium completely changed the texture of the latter, rendering it relatively soft and greatly reducing its tensile strength. Subsequently it was discovered that upon distilling the cadmium from the alloy at a pressure of 0.001 mm. of mercury, the minute quantity of gallium carried through was sufficient to change completely the character of the cadmium

[4]Am. Jour. Sci., 192, 42, Fourth series, p. 389; 1916.
[5]Jour. Am. Chem. Soc., 41, p. 131.

and to prevent adhesion between the cadmium and the walls of the lamp.

The type of quartz lamp used in the experiments is that shown in Fig. 1. The total volume is approximately 10 cc. The electrodes consist of tungsten wires *B* entering through quartz capillaries. These are closed with lead seals similar to the type described by Sand.[6]

In filling the lamp, the cadmium, containing 2 or 3 per cent gallium, is placed in the bulb *F*. It is necessary to maintain the pressure in the lamp and connections below 0.001 mm. of mercury, with the exception of that due to the cadmium and gallium, throughout the process of distilling. Since the volume of the lamp is relatively small, the quartz capillary at *E* should be of such a length as to permit of sealing off in the shortest possible time. The flame used for this purpose should be small and the heating of the tube on both sides of the capillary prevented as far as possible.

The method indicated above, if carefully followed, will yield a lamp with indefinite life. One of this type has been in intermittent use for over a year and shows no sign of deterioration. Should traces of oxide or stains due thereto appear during the process of filling, they can be reduced readily by introducing pure, dry hydrogen and heating. The lamp may be started by heating with a flame to vaporize the metal. It is in all cases advisable to have a current of air blowing upon the lead seals to keep them cool. If the blast is allowed to strike the body of the lamp, the cadmium is condensed and obscures the arc. The most convenient source of energy for operation is the ordinary 110-volt lighting circuit, on which it will operate continuously with a current as small as 3 amperes and


FIG. 2.—GALLIUM SPECTRUM

a drop of 14 volts across the terminals of the lamp. However, the most satisfactory results are secured with a current of about 7 amperes and a drop across the terminals of about 25 volts. Under this condition a practically pure cadmium spectrum of great brilliancy is obtained. The intensity secured is apparently equal to that which would be obtained were the lamp filled with cadmium alone. The map[7] of the spectrum of gallium given in Fig. 2 is interesting. In this connection the wave lengths and intensities of the lines are given in Table 1. It will be observed that there are but four lines in the visible spectrum, and that from practically 4,200 A to 6,400 A there are no lines.

*Table 1.—Visible Spectrum of Gallium.*

| Wave length A | Intensity |
|---|---|
| 3020.61 | 3 |
| 4033.18 | 10 |
| 4172.22 | 20 |
| 6396.99 | 8 |
| 6413.92 | 6 |

When the lamp is operated at a temperature sufficiently high to bring the quartz to a cherry-red color and there is danger of softening the lamp, several gallium lines become faintly visible. The investigations of Uhler and Browning[8] indicate the possibility of two gallium lines 5,353.81 A and 5,359.8 A. However, these lines, if present, are so faint at the highest temperature at which the lamp can be operated that they cannot be identified. The cadmium spectrum is thus obtained in a condition exceedingly favorable for those purposes for which an intense monochromatic light source is indispensable. No gallium lines are found between 4,200 A and 6,400 A, and the gallium lines which are detectable have so low an intensity that they are wholly negligible in polarimetric and other fields of work.

[6]Proc. Phys. Soc., London, 26, p. 127; 1914.
[7]Eder and Valenta, Atlas Typischen Spektren.
[8]Amer. Jour. Sci., 42, p. 389; 1916.

# New Method of Damascening Metals*

## An Ancient Art of Metal Decoration Improved and Simplified by the Aid of Photography

HISTORICAL records show us that more than 5,000 years ago the tempering of copper was a common practice in Babylonia and in Egypt and instruments possessing exceedingly great hardness as well as delicacy of edge and of point were made of this metal and employed by the ancients to incrust the hardest kinds of stone—an art which today must be regarded as practically lost! We are not only ignorant of the processes employed by the ancients in tempering copper but also of the theory and practice of their method of metal working in the art of incrustation.

Damascening, or the art of inlaying, is one of the most admirable forms of technique for beautifying materials ever invented. It is as ancient an art as the tempering of copper; or rather we may say that the tempering of copper was a result of the experience obtained in the technical operations involved in the art of Tausia.

The terms Tausian, incrustation, and Damascening, signify the art of making pictures upon various metals by the inlaying of particles of gold and silver, and the method of operation receives its name from the metal employed as a foundation.

The inlaying of steel and iron with silver or gold is termed Damascening whereas the inlaying of brass and copper with gold, silver or bitumen is called Tausia. The inlaying of brass, copper and bronze and likewise lead with black and silver enamel has received the name of black enameling, or tula, or niello.

As we have remarked, the technique of this process has been mentioned, but it has been nowhere described for us. However, the discoveries made by explorers in ancient lands have revealed to us the complete technique employed by the ancients. Especially valuable are the utensils and vases found, as well as the images of idols, whether Chinese, Japanese, Assyrian, Egyptian, Greek or from ancient India; other instructive objects are the Roman votive tablets and incense burners, as well as the Italian drinking vessels, weapons and sacred statues; likewise the armor of the kings and emperors of these times, which were partly inlaid with silver, gold, or pure copper, and partly with neillo bitumen.

This art was but lttle exercised during the Middle Ages. Not until the 15th century did the art of Tausia begin somewhat to revive, being employed by the makers of plate armor and weapons of gold and silver. This craft was especially practised in Milan, Brescia, Madrid, Toledo, Venice, Rome, Tuscany, Augsburg, Nuremberg and Munich. However, the long continued wars of this period caused the art of Tausia to fall into neglect and it was not until the 17th century that an endeavor was made to revive and develop it.

This revival first exhibited itself in Russia, and the objects made by these craftsmen made their appearance in trade under the name of Tula silver. It certainly seems odd that at a time when human taste is so highly developed as at present the art of genuine Tausia should be so little practised. This is all the stranger since today the manufacture of commercial objects has reached a degree of perfection which was unattainable to the artists who lived 6,000 years ago.

Our industries confine themselves, with few exceptions, to a mere imitation of genuine art and this, unfortunately, is to the disadvantage of the object manufactured. We need only recall the so-called colorings produced in brass, copper, silver, gold, and nickel by manufacturers to perceive that such crude effects can in no way be compared with these genuine antiques.

If we wish to practise the genuine art of Tausia, the first question is as to the nature of the object upon which it is to be applied. For instance, let us suppose that the tinsmith and metal molder have made a copper vase one meter in height, and that the latter is to receive an incrustation of silver and gold in accordance with a prescribed text and drawing, the latter being an arabesque containing motifs from human life. First of all the drawings must be imprinted upon the vase. This can be accomplished by means of small notched wheels having points as hard as steel and as sharp as needles; after the drawing has been pasted upon the surface of the object, these tracing wheels are run over the different lines of the drawings with a moderate degree of pressure. The perforated lines thus produced are then indented with a graving tool and the ground cross-hatched or roughened.

Particles of gold and silver which had been previously cut and then bent off are now placed in the lines of the drawing and hammered firmly in with a small round hammer. The particles of the metals at once unite with the ground and require no further treatment. It is now, of course, a mere matter of taste as to whether the drawing is left as a composition of gold and silver upon the red background, or whether this red background is transformed into a black one. This transformation could likewise easily be effected by merely placing the incrusted vase in a solution consisting of one liter of water, 200 gr. of copper sulphate, 750 gr. of aqueous ammonia having a specific gravity of 0.96 and allowing the saturated solution to take effect for about half an hour. The vase is then thoroughly washed in clean sawdust; silver and gold will be unaltered, whereas the copper vase is now of an intense black color.

If the drawing is to be inlaid with silver and tula, it is best first to fuse the tula or enamel with the flame of a blow pipe. Not until this has been done are the silver particles hammered into place. The drawing will then show in strong relief against the copper in tones of white or dark gray.

It is evident that this kind of work is quite profitable in spite of the expense of the material, but nowadays this sort of individual labor is insufficient to satisfy the demands of either the public or the workmen. Products must, as a usual thing, be made on a large scale at the present time.

To accomplish the production of such genuine enameled, inlaid, incrusted metal ware it is necessary to inlay the smooth surface before the metal object is shaped. This, of course, cannot always be done, but it is possible in the great majority of cases.

The first step, therefore, is to cut the sheet metal roughly with an eye to the nature of the object to be manufactured and the dimensions of the drawing. In making the drawing extreme care is taken to see that in the copy the picture to be manifolded falls at exactly the right place, so that after it is imprinted, etched and incrusted it will fall in the exact middle of the metal plate. The metal plate which is to be imprinted or otherwise treated is stamped or punched after the incrustation, and is then ready for further treatment. When all of the separate parts have been made ready and mounted the objects can be polished or ground as desired. The process thus described, therefore, includes the following steps:

1. Preparation of the metal.
2. Preparing the drawing.
   a. By tracing from the original.
   b. By photography.
3. Preparation of the copies.
   a. The negative.
   b. The positive.
4. Transferring the copy directly to a metal plate.
5. Blacking in the copy.

*Translated for the *Scientific American Monthly* from the *Elektrotechnische Zeitschrift* (Berlin), Oct., 1919-Jan., 1920.

6. Making the impression.
7. Powdering and firing.
8. Etching.
9. Punching.
10. Mounting.
11. Polishing, varnishing, waxing.

The drawing upon the page to be etched can be most conveniently transferred by means of a blue indigo paper. But this can also be accomplished by using gutta percha dissolved in alcohol, and painting the object by means of a brush with this solution. When it is done there remains upon the plate after it is dried a thin film of a grayish yellow and upon this film the drawing can be traced to correspond with the original. Thereupon all the parts that are not to be etched must be covered with asphalt varnish or, if possible, also with an impression color-wax also, whereupon it is ready for etching.

Since this process cannot be employed for the gross production of articles, the process of photographic impression is made use of. By means of photography different copies of an original drawing can be manifolded in the greatest variety of sizes and in exact correspondence with the original which can then be kept for future use. The principal feature of the photographic process is the enlargement of the original drawing.

The drawings must always be made upon perfectly white cardboard with black India ink and in such a manner that they consist only of points and lines, tones being absent. After the drawing is perfect in all respects the next step is to make a negative, *i.e.*, a glass plate upon which a reversed image of the original is seen, both as regards color and position. In other words the black lines of the original show white upon a glass plate and are therefore transparent whereas the white ground is black upon the negative and therefore non-transparent. When a piece of sensitive paper is placed underneath such a negative a positive copy is obtained corresponding perfectly to the original in the smallest details. In order for the drawing of the positive to stand out as absolutely clear from the white ground as in the original the negative must consist of absolutely black, non-transparent portions and absolutely white, perfectly transparent portions.

When it is desired to obtain negatives without photographs a glass plate is covered with a colored gelatine layer, which allows no light to pass through it. The drawing is made upon this with the needle and the rasper. The operator then proceeds as follows: To begin with a glass plate is carefully cleansed and then covered with a mixture consisting of 10 gr. of gelatine-bone glue in 100 gr. of water in which carbonic acid lead oxide has been stirred until it is of the consistency of broth. Before being applied, however, this mixture must be carefully rubbed upon a color block, so that there is no danger of any bubbles being formed upon the glass plate. It is important also that the gelatine layer should exhibit no transparent or translucent spots. This layer is dried in the air at a moderate temperature. The drawing is then covered with "balquir" paper, and the plate is laid with the glass downward upon a black cloth and the drawing is etched in. The particles of gelatine which have been removed are brushed away with a soft, broad paint brush. In order that the plate or gelatine layer shall be non-sensitive to light it is immersed in a solution of sulphuretted hydrogen (this is obtained by dissolving in 100 parts of water 1 part of sulphuric acid and 1 part of iron pyrites or of cuprous sulphide) which changes the white lead oxide into a brownish yellow lead sulphide. A disagreeable accompaniment of this last operation is the extremely offensive smell of the sulphuretted hydrogen, and it is desirable, therefore, to transform the lead oxide either in a separate room or in the open air. After the plate is dry it is varnished. When copies are to be prepared directly upon small plates, whether this be done by means of the asphalt process or by mean of the albumin process, these negatives upon glass plates are not very practical. In this case a negative film is employed. This is prepared as follows: An unvarnished negative prepared according to the collodium process is washed several times with warm water and afterwards covered with a so-called leather gelatine.

The negative must be well powdered and laid perfectly horizontal. The leather gelatine is poured on until it has been distributed evenly over the entire negative glass plate. If air bubbles make their appearance they must be destroyed with the point of a sheet of the finest tissue paper.

The leather gelatine consists of the following components:

| | |
|---|---|
| (a) 8 gr. of gelatine or | (b) 1 gr. of gelatine |
| 4/10 gr. of glycerine | 4/10 gr. of glycerine |
| 1 gr. glacial acetic acid | 9 gr. of water. |
| 70 gr. of water | |
| 15 gr. of alcohol | |

The gelatine is first softened in cold water, then melted and then immersed in a hot water bath, after which it is allowed to cool to the temperature of 40 deg. cent. and filtered through muslin. The amount required for coating the negative—which is lying in water—is about 3.8 ccm. of the leather gelatine per 10 sq. cm. of the surface. In order to secure the precise placing of the negative to a leveling stand by means of whose screw foot the negative can readily be made exactly horizontal by the aid of the water level. When the leather gelatine has congealed upon the negative, the latter is allowed to remain in position for two or three days; the film is cut along the four edges and carefully removed and preserved in a stout book of suitable size.

While the light is taking effect the negative must remain in close contact with the sensitive paper or with the sensitive plate of metal or glass. In order to accomplish this the photographic copying frame is employed. If it is necessary to have a very strong pressure then the springs of this frame must be replaced by wedges of wood, from three to five of which must be inserted each time under each band.

If it is desired to make a copy of a glass negative upon paper the negative is laid with the side containing the picture or drawing upwards upon the reflecting plate and place the prepared side of the sensitive paper upon the negative. Finally, about two dozen sheets of soft paper are laid upon it and covered with black cardboard; the frame is then locked and the proper pressure applied for printing.

In order to obtain perfect work various manipulations must be performed in a dark room. . . .

We now come to point 5—the blacking in of the copy and next to point 6, the impression. The process of photo-chemical printing is based upon a property of chrome gelatine, which under the effect of light beneath a photographic negative ceases to swell and absorbs printers' ink, while those parts not affected by the light readily swell and do not absorb printers' ink.

The process is in general as follows: A piece of paper covered with gelatine is placed in a solution of double potassium chromate to be made sensitive to light, after which it is dried, placed under the negative and exposed to light. After the exposure is finished the layer of gelatine is lightly covered over its entire surface with thick printers' ink and the copy then laid in cold water for about fifteen minutes. When a damp sponge is passed over the blackened copy the ink is wiped from the unilluminated portions while it adheres firmly to the illuminated portions. In this way, therefore, we obtain a positive copy upon the sheet of paper or of metal.

It has been observed by operators that it is rather difficult to remove the ink from the unilluminated gelatine by means of the damp sponge referred to. On this account the experiment was made of covering the sheet of paper or of metal with chrome albumen. However, this was not found satisfactory since in this case the sponge readily removes the printers' ink from those parts which are free of the albumen, and this gives blurred outlines.

A paper is now employed, therefore, which contains a layer of albumen placed upon a layer of gelatine. Since the non-

exposed portions of the albumen layers are soluble in water the sponge easily and rapidly removes the albumen and the printers' ink it contains. Meanwhile the gelatine substratum prevents the paper from being marred by the process of washing. By this means the danger of injury to the drawing is practically avoided. In order to sensitize the so-called Husnik paper a chrome salt bath is employed of the following composition:

1 gr. double potassium chromate
14 gr. of distilled water
4 gr. of alcohol.

When the solution of the salt has been accomplished, aqueous ammonia is added until the solution assumes a deep yellow color. While the addition of the alcohol prevents the albumen layer from being dissolved in water, the ammonia causes the transformation of the double potassium chrome into a less sensitive double salt of potassium chrome and ammonium chrome, which, however, is again transformed into the double chrome salt after the ammonia has been evaporated from them.

About as much paper is prepared at one time as can be used upon the following day. When the paper has been carefully removed from the bath, being held by two corners, it is allowed to drain and dry in the dark room.

After the paper is dry, which requires from 12 to 16 hours, it is pressed firmly together with the negative and exposed to the light; from one to four hours is required in the sunlight and ten to twenty hours in the shade, but sometimes from 60 to 180 minutes suffices if the light is strong enough. When the negative is placed directly upon a printing plate—whether it is zinc or aluminum—the following operations are observed:

1. Cleaning of the plate with matting.
2. Preparation of the plate.
3. Exposure of the latter for a longer period of time than when paper is employed.
4. Rolling up and development of the copy.

The aluminum plate is first cleansed from possible grease or oil in benzine, and then has its surface dulled by being placed in 5 per cent solution in water of hydrofluor-silicic acid. It is now given an even mat surface by means of a soft mat surface by means of a soft piece of felt and the finest piece of felt and the finest powdered sulphur. The plate which was previously washed in pure water now assumes a slightly gray aspect.

The aluminum plate after being thus prepared is coated with a sensitive layer composed as follows:

2,000 grs. distilled water.
48 " Egg-albumin.
7 " chromammonium.
100 " aqueous ammonia.

After being dried the photographic negative is put together with the plate thus prepared (all operations being conducted in a dark room), in a copying frame and exposed to the light under strong pressure. The exposure requires from one to two minutes in the sunlight and from five to ten minutes in the shade.

Since there is danger when there is too long an exposure that the color might be rubbed away from the exposed portions, it is advisable not to open the copying frame, to make use of a photometer. In order to do this the photometer box is filled, the cover closed so that the strips are pressed firmly by means of the spring against the transparent scale through which the light penetrates, coloring the strips brown. Printed figures and letters which stand out clearly upon the dark ground of the chrome paper strip indicate the places to which the effect of the light has penetrated. After a few trials one readily finds the photometer degree corresponding to a suitable length of exposure with the correct exposure time after the ink has been applied. The latter is readily removed from the unilluminated portions provided that too much ink was not employed.

The copy goes now from the photograph to the stone press, where it is printed and manifolded by means of a metal hand press or of a rapid press, indirectly by means of rubber upon properly punched pieces of sheet metal, which have been previously cleansed.

As stated above the drawing must go exactly in the middle of the sheet of metal in order that it may be in the correct position on the mounted article. When there has been no error in the calculation it is possible by means of a press to make from 150 to 200 copies in eight hours, after a little practise.

Upon the rapid press this can be sextupled, but constant care must be taken to have a perfect press layer. So soon as the ground metal becomes fixable in fine point and after the pouncing and firing the plate exhibits a grayish-brown color one may know that the press layer is too light. According to the sort of drawing employed an etching may occur frequently, but in most cases, however, the etching liquid will strike through, i.e., it will attack the ground metal in those portions which ought to be protected; it is obvious that in the case of works of art this must never be allowed to occur. For this reason it is of prime importance to use a printing color which is unobjectionable. Such a color may be prepared by any of the following four methods:

a. 16 grs. mastic.
50 " Burgundy resin.
125 " Wax.
200 " Asphalt.
500 " Oil of turpentine.

b. 8 " Lithographic printer's ink.
1 " Wax.

Add turpentine until the measure is of the consistency of syrup.

c. 125 Grs. Wax.
120 " Tallow.
100 " Vaseline.
130 " Elemic resin.
1800 " Black ink.

Add a very small amount of moderately stiff varnish.

d. 4 grs. Wax.
1 " Venetian soap.
1 " Venetian turpentine.
1 " Mastic.
1 " Borax.
1 " Spermacetti.
1 " Colophonium.
1 " Tamar resin.
1 " Oil of lavender.

When a sufficient number of plates have been printed they are then powdered and fired in order to protect the drawing from external influences, such as the action of water and acids and the effect of handling.

In order to accomplish this it is necessary at once to powder the still damp print with French chalk and asphalt and then to dust it off with delicate, regular strokes by means of a very fine hairpin, after which it is slightly warmed in a gas oven. If this warming process continues too long, the burned print color cannot be removed by the subsequent washing with benzine or with benzol (benzene). After the burning in or annealing which follows, the rear side of the printed sheet of metal is coated with asphalt varnish in order to protect it against the effect of the acid during the process of etching. A certain amount of retouching must also be done, varying according to the quality of the print, i.e., faulty, or uncovered portions of the drawings or injuries of the latter must be covered with asphalt varnish by means of a fine paint brush. It is now ready for the etching. It is obvious that in the case of such incrustations as are here in question different acids and different chemicals must be employed for each kind of metal or alloy. It is not the purpose of this article to give a detailed account of such work, but merely to show the way in which the ancient art of "Tausia" can be revived.

In order to etch in the drawing a solution of hydrochloric acid, chloride of iron (ferric chloride) and chlorate of potash is used. This solution should have an average temperature of 25°C. If the drawing is of such a sort as to include broad surfaces together with very delicate lines, or when the article is to be black enameled (niello) it bcomes necessary to interrupt the etching process at the end of about half an hour, to dry the plates in the gas stove, and to cover the line drawing with asphalt varnish. Not until this is done can the etching be continued till it attains the desired depth. As soon as this is reached the plate is rinsed off in clean water and then either incrusted or nielloed.

For this purpose there are employed mechanically prepared particles of precious metals which are hammered in to the lines of the drawing, or else, when these are too delicate for such treatment, deposited by means of a galvanic bath. Those portions which are to become silvered, in the latter case are first covered with asphalt varnish; after this the article is suspended in a bath until it acquires any desired color. After each separate coloration the coating of varnish must be washed off and the drawing recoated, each time omitting the portions which are to be colored.

When niello is to be used it may be prepared by one of the following three formulae:

| | Chemically pure | | |
|---|---|---|---|
| Fine silver | Copper | Lead | Sulphur |
| 1 parts | 2 parts | 3 parts | 12 parts |
| 3 " | 5 " | 2 " | 18 " |
| 1 " | 1 " | 5 " | 6 " |

| Fine silver | Copper | Lead | Sulphur | Sal Ammoniac |
|---|---|---|---|---|
| 2 parts | 4 parts | 6 parts | 18 parts | 4 parts |
| 1 " | 1 " | 2 " | 4 " | ½ " |
| 3 " | 7 " | 10 " | 20 " | 5 " |
| 3 " | 10 " | 1 " | 10 " | 2 " |

| Fine silver | Copper | Lead | Sulphur | Borax |
|---|---|---|---|---|
| 2 parts | 5 parts | 3 parts | 20 parts | 1 parts |
| 3 " | 4 " | 2 " | 24 " | 2 " |
| 4 " | 8 " | 3 " | 28 " | 3 " |

The copper and silver are first fused together and when the molten metal has somewhat cooled off the lead is added. In a second crucible sulphur and sal ammoniac are fused together, well stirred and poured into the molten metal. The flux is then poured into cold water and thoroughly stirred with an immense broom. The grains obtained in this manner are finally pulverized in a mortar and preserved in the state of powder.

When the article has been etched the operator takes as much of this prepared powder as is required by the design, stirs it into a small amount of sal ammoniac solution to form a sort of broth and then fills the crevices of the design with the latter. Heat is now applied until the inlaid particles are fused, after which the object is allowed to cool and then polished. The polishing of all three models can be done either with steel or with blood stone and a revolving swab.

When the article is thus far ready there follows the rolling, pressing, and finally the printing of the separate parts as well as the mounting. When the object is entirely finished it receives a final polish.

# Catalysis by Means of Precious Metals*

## The Use of Platinum and Palladium in Various Forms as Catalytic Agents

CERTAIN metals have an action termed catalytic, which is manifested in three different forms, namely, hydrogenation, oxidation, and molecular splitting, upon certain bodies placed in contact with them in a current of hydrogen or of oxygen; these reactions take place without modifying the metal. The origin of this process, which at the present time is assuming considerable industrial importance, goes back to the experiment performed by Davy (1817) in combining hydrogen and oxygen in contact with a heated leaf of platinum. Platinum is one of the best catalyzers known, especially when in a divided state, in which case it is known as platinum *moss* or platinum *black;* the related metals (palladium, rhodium, iridium, and osmium) and likewise silver, possess analogous properties.

*La Journal des Usines à Gaz* (Paris) (Gasworks Journal) publishes in the numbers for June 20 and July 5, 1919, an article upon this subject, by M. Mailhe, from which we abstract the following paragraphs.

### HYDROGENATION.

In contact with platinum black, in the cold, double valences are saturated with hydrogen. Thus ethylene is changed into ethane; in the same manner acetylene attaches to itself, in the cold, four atoms of hydrogen, becoming transformed into ethane. Anylene yields pentane. Pinene and camphene are totally transformed in the cold into the corresponding dihydrides:

$$C_{10}H_{16} + H_2 = C_{10}H_{18}$$

These reactions are effected in a very simple manner. The substance to be hydrogenated is placed in a receptacle which communicates with a graduated gasometer containing hydrogen under a constant pressure; the said substance may be taken just as it is, or it may be previously dissolved either in a neutral solvent or in ether. A certain amount of platinum black is then added and the mixture is agitated mechanically in order to keep the platinum in a state of suspension in the liquid mass. A rapid absorption of hydrogen at once begins to take place becoming slower in proportion as the substance becomes saturated. When the transformation is complete the level of the hydrogen in the gasometer ceases to fall.

By means of this treatment incomplete acids and alcohols are saturated at the point of the double valence. Allylic alcohol yields propanol; oleic acid leads to stearic acid and the oleic ethers to stearic ethers, a reaction which finds an industrial application in the *hydrogenation of oils.* Finally, the aldehydes and the cetones are changed into primary and secondary alcohols.

The hydrogenation of the benzenic nucleus was long considered to be peculiar to divided nickel, but in 1891 Vavon proved that platinum black can occasion the same phenomenon. In attempting simply to saturate the double valence of benzylidene-cetone, $C_6H_5CH = CHCOCH_3$, by agitation in the cold with hydrogen in the presence of platinum black, he observed at the beginning a very rapid rate of absorption of the gas which later diminished, the reaction finally terminating with extreme slowness. The product obtained, which was definitely hydrogenated, was *cyclohexyl-butanol*, $C_6H_{11}CH_2CHOHCH_3$. Thus in this case not only the double valence and the cetone group each fix two atoms of hydrogen, but the three double valences of the benzenic nucleus disappear as a consequence of the fixation of six atoms of hydrogen.

*Platinum moss.*—Platinum moss is a less active catalyzer of hydrogenation than platinum black, and in the majority of cases it is necessary to fix the hydrogen at a much higher temperature. However, in 1913, Wilstaetter succeeded in accomplishing the hydrogenation of a large variety of aromatic com-

*Translated for the *Scientific American Monthly* from *Le Genié Civil* (Paris), October 25, 1919.

pounds in contact with platinum moss at ordinary temperatures. Benzene is transformed into cyclohexane, and, as in the case of nickel, the reaction is prevented by the presence of traces of thiophene. Toluene, xylene, and durene yield hexa-hydrogenated derivatives. Naphtaline fixes ten atoms of hydrogen, yielding deca-hydro-naphtaline with a boiling point of 185°C. Phenol leads to cyclo-hexanol, amyline to cyclo-hexylamine, etc. On the whole, platinum moss, like nickel and like platinum black, readily secures the hydrogenation of the aromatic nuclei. It is likewise an excellent catalyzer for the fixation of hydrogen upon oleic acid, which is thus changed into stearic acid.

*Palladium.*—Palladium in its various forms possesses in a far higher degree than platinum the property of absorbing considerable quantities of hydrogen. At 200°C. palladium moss fixes 686 volumes of hydrogen, while palladium black absorbs 852 times its own volume. Consequently, this metal . . . may be used in the same manner as platinum as a hydrogenation catalyzer.

Precipitated palladium, obtained by the action of zinc upon the chloride of palladium, has already been employed by Zelinsky to transform the cyclic bromides and iodides into the corresponding carbides. Breteau has applied it to the formation of the hydrides of phenanthrene. With palladium moss derived from the calcination at a low temperature of palladium chloride we thus arrive at the octo-hydride of phenanthrene, $C_{14}H_{18}$; but it is necessary to operate at a temperature of from 150 to 160°C.

The *Spongy palladium* obtained by electrolysis and the *palladium precipitated by the aid of sodium hypophosphite* are likewise capable of producing various reductions.

Among industrial syntheses that of *ammonia* is undoubtedly one of the most interesting by reason of the tremendous importance of this substance. As we know its formation by means of nitrogen and hydrogen: $N_2 + 3H_2 = 2NH_3$, is an exothermic reaction. This compound would be destroyed at a high temperature. Consequently this reaction must be accomplished at as low a temperature as possible (about 500°C.) by employing a catalyzer designed to increase its rapidity. Moreover, in accordance with Le Chatelier's law with respect to the disturbance of the equilibrium by a variation in the pressure, this operation must be carried on with as high a pressure as possible. But *osmium* was the first catalyzer employed by Haber and Le Rossignol to effect the synthesis of ammonia. By its use it is possible to unite the hydrogen directly with the nitrogen at a temperature of 550°C. and under a pressure of 180 atmospheres. However, this metal is still so rare that its use is as yet impracticable.

### OXIDATIONS.

Platinum and palladium fix oxygen in the same way that they absorb hydrogen. Platinum in thin leaves absorbs from 63 to 77 times its own volume, whereas palladium in the same form absorbs a thousand times its volume.

Platinum is the classic catalyzer of oxidation. When ordinary alcohol is allowed to fall upon platinum black a violent reaction immediately occurs, with the formation of aldehyde:

$$CH_3CH_2OH + O = H_2O + CH_3COH.$$

In the same manner all of the alcohols are changed into aldehydes through their oxidation by means of the oxygen of the air. This reaction is extremely violent, so much so, in fact, that a portion of the aldehyde is destroyed; it can be moderated by employing platinized asbestos.

The most important oxidizing reactions effected by the precious metals are those connected with the manufacture of sulphuric anhydride and of ammonia and with the transformation of methyl alcohol (commonly known as wood alcohol), into formol.

The manufacture of sulphuric anhydride from $SO_2$ and atmospheric oxygen in contact with platinized asbestos, heated to 400°C. is too well known to be described here.

The transformation of methyl alcohol into formol or formaline is accomplished perfectly in the presence of platinum black. By directing upon this catalyzer a mixture of methanol and air we obtain formic aldehyde. Formaldehyde lamps are based upon this reaction. The preparation of formic aldehyde having become a reaction of great industrial importance a considerable number of inventors have sought to improve the process. Most of the patents obtained in this connection are based upon the use of silver as a catalyzer. This metal is deposited upon asbestos or upon pumice stone, or is utilized in the state of the moss. 200 gr. of silver nitrate for example are dissolved in 500 gr. of water; 100 gr. of asbestos wool are then placed in the solution and the temperature is raised to cc. 90°C. The silver is precipitated by the addition of formic acid or of formol. After the solution has been evaporated to dryness the asbestos is carded, proper precautions being taken.

In a German patent formaldehyde is manufactured through the oxidation by means of air of methyl alcohol in contact with catalyzers formed of couples of metals, such as silver upon which there has been deposited platinum, rhodium, or some other metal of the platinum group. Thus silver alone gives a yield of 75 per cent of formaldehyde; a couple composed of silver and rhodium (1/10,000 of the latter) yields 96 per cent of the aldehyde, and a platinum-silver couple yields the same percentage.

### MOLECULAR DIVISIONS.

Besides the two reactions of hydrogenation, the precious metals are capable of effecting molecular divisions or "splittings," some of which are quite curious in character.

A very well known phenomenon is that of the decomposition of the peroxide of hydrogen by silver in a pulvarulent condition, oxygen being liberated upon the contact of the two as follows:

$$H_2O_2 = H_2O + O$$

In the same manner rhodium black decomposes formic acid in the cold into carbonic anhydride and hydrogen:

$$HCO_2H = CO_2 + H_2$$

The hypochlorites are likewise destroyed by this metal, setting free oxygen:

$$ClONa = NaCl + O$$

Platinum black and palladium black, which so readily fix hydrogen upon the aromatic nucleus, at a low temperature, dehydrogenate the cyclo-formenic carbides at a higher temperature, regenerating the benzenic carbides. Thus, at a temperature above 180°C. palladium dissociates cyclohexane into benzene and hydrogen:

$$C_6H_{12} = C_6H_6 + 3H_2$$

In the same manner that platinum moss and palladium moss effect the hydrogenation of the aldehydes and of the cetones they occasion the splitting up of the primary and secondary alcohols, which are changed into aldehydes and cetones. Benzhydrol, in particular, yields benzo-phenone:

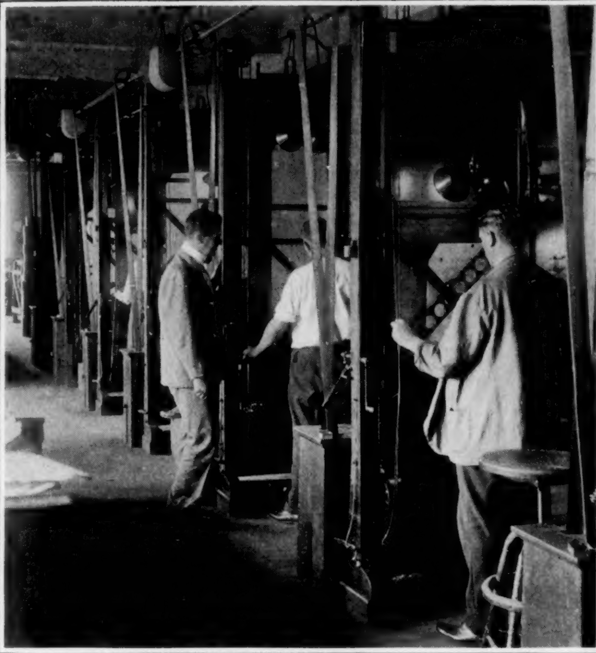
$$C_6H_5CHOHC_6H_5 = C_6H_5COC_6H_5 + H_2;$$

ordinary alcohol leads to acetaldehyde, and secondary propanol to ordinary acetone.

Finally, Délépine, upon boiling sulphuric acid containing ammonium sulphate, together with leaves of platinum or with platinum moss, observed a loss of nitrogen, the greater the prolongation of the experiment the greater being the said loss. Since the platinum had not changed in weight it is evident that the ammonium sulphate is decomposed by catalysis.

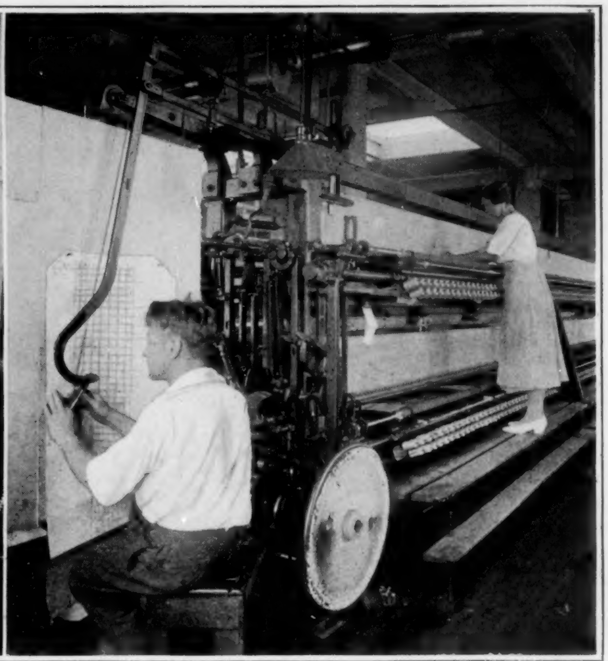
## PROTECTING MINE TIMBERS FROM FIRE.

MAGNESITE cement is recommended by W. C. Phalen (*Engineering World*, March, 1920) as a fire protection for mine timbers. The stucco should be applied in two ¼-inch coats to a dry surface. If the temperature is above 50 deg. fahr. the finishing coat must be laid on before the first coat has hardened.



PREPARING THE PAPER ROLLS FOR THE AUTOMATS

The card-room where highly trained men interpret designs into holes that are punched by machine into rolls of paper. The latter through the automats control the functions of the Schiffli embroidery machine.



OPERATING A "SCHIFFLI" BY MEANS OF A PANTAGRAPH

The man or "stitcher" is tracing a design before him. The girl is rethreading a needle. By lifting the frames carrying the fabric several lines of embroidery may be worked on each strip of material.

# Machine-Made Laces and Embroideries

## Automatic and Semi-Automatic Machinery for Working Out Intricate Designs

### By Robert G. Skerrett

AMERICAN women spend annually more money than their sisters of any other nation in the embellishment of their garments with trimmings of one sort or another. For this purpose laces and embroideries of many kinds are lavishly purchased, and the wide-spread feminine taste for finery could not be satisfied if nimble fingers alone were depended upon for these products. Mechanical agencies today turn out by far the largest part of the ornamental fabrics in question, and the manner in which these machines function is little short of marvelous.

The industry of machine-made embroideries had its start in the United States thirty years ago, but the art has constituted the basis for a splendid business in Europe for a much longer time. The manner in which Americans first obtained these trimmings in commercial quantities is worth recalling because it discloses how the trade name used here for a considerable period effectually misled as to the origin of the earlier consignments of these goods. "Hamburg lace" was a household term among our mothers and our aunts, and most persons believed that these washable fineries came from Germany. There was a reason for this misunderstanding.

An enterprising Yankee, nosing about in Europe, happened upon the St. Gall district of Switzerland where he found some thousands of people engaged in the manufacture of embroidered cotton goods, and he promptly appreciated that our own womankind would be only too glad to pay well for these commodities. In fact, he was so satisfied that the home market would be a worth while one, that he determined to hide the source of his shipments to America so that he could monopolize the trade in this country. Therefore, he had his packages sent to Hamburg and cleared from there to the United States. So far as buyers on this side of the Atlantic knew for years the trimmings they admired had their genesis in the German city. Eventually, the embroideries of St. Gall reached our shores through other channels, and their Swiss creators obtained the credit which was rightly theirs.

For decades, the artisans of St. Gall used only hand machines in the making of embroidered fabrics. It was not until 1886 that power-driven machines were built capable of competing successfully with the manually-operated apparatus. At that date, there were in service just six efficient power machines in the St. Gall district, but from then on their development and adoption became rapid. In 1894, newer and bigger machines were brought out, and by 1908 there were approximately 6,000 of these engaged in the Swiss embroidery industry. The designers of the power apparatus were not able to duplicate the work made possible by the hand machines; to state it broadly, they limited their efforts to adapting the sewing machine stitch to textile decoration; and to accomplish this a good deal of ingenuity was required.

In the hand machine, the needle passes entirely through the fabric, drawing the thread after it, and then reverses this motion much as a human embroiderer does. For that reason the stitching is alike on both sides of the foundation material. This, of course, produces the best and the more costly goods. The "schiffli" or power machine is so named because of the boatlike shape of its multiple shuttles—schiffli being the Swiss diminutive for ship. In this apparatus the needle functions horizontally but otherwise just like that of the familiar sewing machine. As the needle starts to retreat the thread loops on the wrong side of the cloth, and through this loop the shuttle carries the thread wound upon its little bobbin—form-

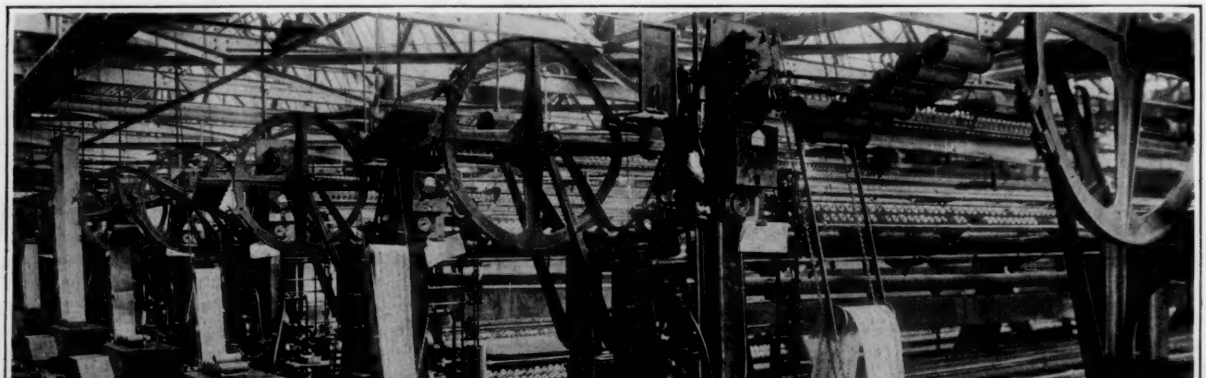
ing in this way a lock stitch. Therefore there is a wrong and a right side to the work. The alternate movements of the needle and the bobbin serving to draw the stitches tight.

Schiffli machines are capable of stitching a repetitive design simultaneously upon two strips of material, fastened in an upper and lower frame, each having a length of from 6¾ to 10 yards; and according to the size of the pattern or "repeat" as it is called, the number of needles varies. A 10-yard machine is equipped for a total of 678 needles with a corresponding number of shuttles, and all of these are used only when reproducing a 4/4 design, *i.e.*, one a trifle more than an inch wide. We shall learn presently how, by employing fewer needles, it is possible to embroider wider repeats or bigger single patterns. No matter what the number of needles used may be, all of them act in unison, so that each one of them does exactly the same work, makes the same stitch, at the given instant. In other words if 678 needles are in service, they simultaneously reproduce the design 678 times. By reason of this disposition, the needle to the left finishes its stitching where the one immediately to the right began, and in this way a continuous strip of embroidery is produced. There are, of course, two rows of needles—one to stitch the upper length of cloth and the other to embroider the fabric stretched upon the lower frame of the machine.

For a 6/4 pattern, in which the repeat is about 1.6 inches wide, the needles are set accordingly, and each of the two rows carries, in the 10-yard machine, 226 needles with their corresponding shuttles and spools of thread. Machines doing 8/4 designs or 12/4 patterns use 338 and 226 needles respectively. To avoid loss of time, and the somewhat vexatious work of respacing the needles to accommodate repeats of different dimensions, it is customary to adjust a machine for a given size of pattern and to keep it running only on work calling for that span. Thus the various machines in a factory are ready at hand to deal with the standard widths of the trade. But the interested layman will ask: "How is it possible, with a needle moving back and forth on a fixed line, to stitch upon the cloth the intricate motif of the artist's planning?"

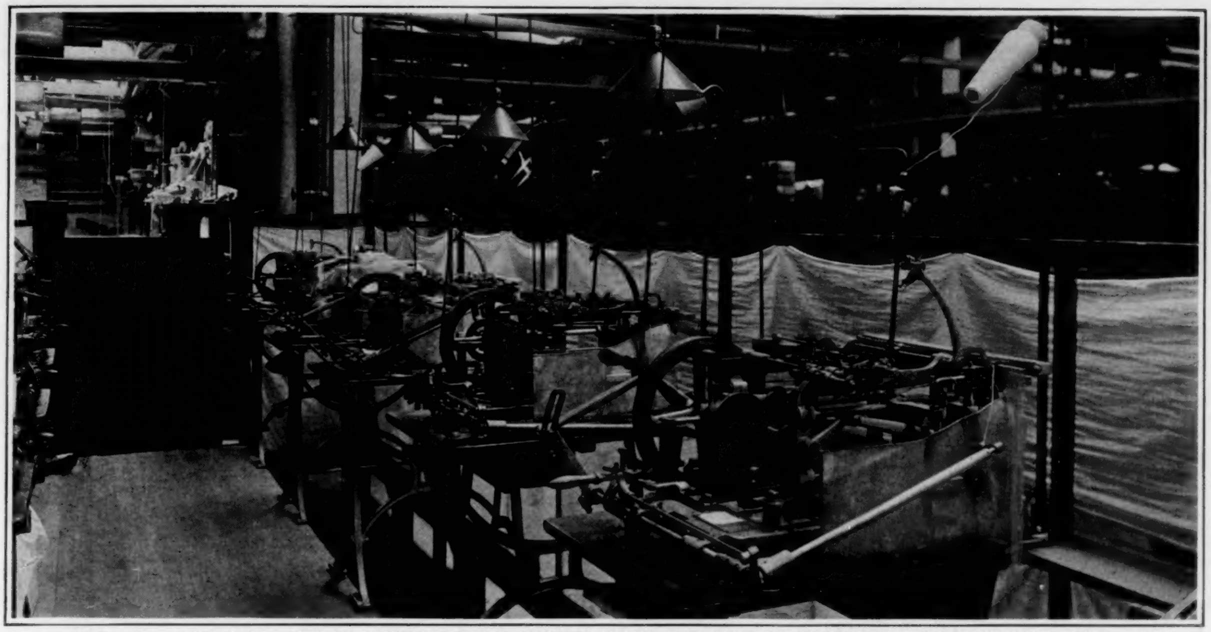
On the sewing machine, with which most of us are familiar, a skilful operator can trace all sorts of lines simply by shifting the material—the needle the while making only an up and down movement. In the case of the embroidery machine, the frames carrying the fabric stand upright and are capable of vertical and horizontal travel. Thus in a plane perpendicular to the motion of the needles it is practicable to guide the material freely and by this means cause the needles to place their stitches wherever desired. The frames operate in concert, and their motion, within definitely prescribed limits, is regulated by mechanical facilities which are, themselves, brought into play by suitable controlling agencies. The latter are of two sorts in the schiffli machines: those using modifications of the Jacquard attachment and those in which the functions depend upon a pantographic arrangement which is primarily guided by a highly trained operative.

While all of the embroidery machines now in this country are of either Swiss or German make, still certain improvements have been brought out here which have added much to the effectiveness and the speed of working of the foreign-built apparatus. The "automat," so called, is conspicuous among these developments of the art, and was invented here by a man of Swiss birth, J. Groebli. The Groebli automat carries a perforated roll which, to the uninitiated, looks not unlike that used in a piano player. As this roll is unwound by an electric motor, the perforations allow little rods or pins to project, which, in turn, dominate the actions of more rugged mechanisms that shift the frames agreeably to the pattern punched upon the cardboard strip. In this manner are brought into play at the proper moment cutters which pierce and clear away the fabric for the working of eyelets. All the while, of course, the needles are continually active. The Groebli automat can be attached to any schiffli machine, and makes it



A ROW OF AUTOMATS AND THEIR RESPECTIVE SCHIFFLI MACHINES

Each machine is capable of working simultaneously upon a total of twenty yards of fabric, and it is possible to turn out 600 yards of embroidery per day when operating at full speed.

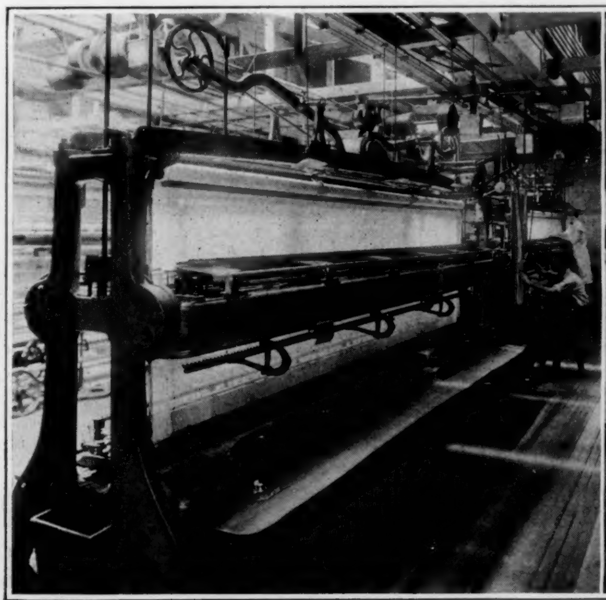


A GROUP OF AUTOMATIC NEEDLE THREADING MACHINES, EACH CAPABLE OF THREADING 25,000 NEEDLES PER DAY

possible to increase the number of stitches per minute anywhere from 25 to 30 per cent over that of the ordinary schiffli machine controlled by pantograph.

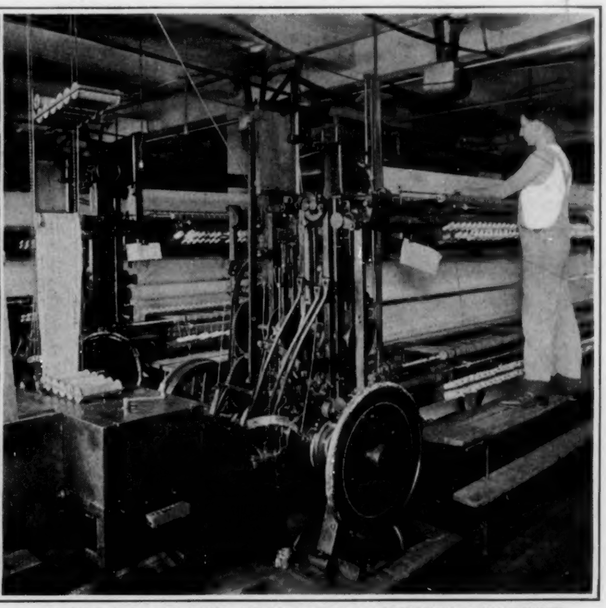
The success of the Groebli automat, so far as the finished embroidery is concerned, is contingent upon the way in which the "card" is perforated by the craftsman whose especial training has made him fit to translate the original design into motion and stitches to be executed by the schiffli apparatus. To begin with, it is essential that this expert shall be thoroughly familiar with the capabilities of the embroidery machine. His aim is to make every stitch count effectively, if possible, and to hold down to a minimum the number of operative moves for any given design. The general procedure in the manufacturing establishment is as follows: First, the artist produces a pencil sketch, actual size, which serves as a sample for initial orders. Next, this design is enlarged by a draftsman on a scale six times that of the original drawing, and hatched to indicate the general direction and character of the stitching.

In the punching room, the design is tacked to a vertical board before which the automat card-maker stands. Two diagonal strips of metal straddle the design, and these can be slid independently up and down so as to bring their upper intersection to any point over the underlying drawing. Two cords control these motions, and a third one, operated by the little finger, causes the punching machine to make, at the desired spot on the card, the required perforation. Off to the right of the card-maker is a single unit of the embroidery machine which works on a vertical piece of fabric the design as it is being punched. Thus, he has a guide and a



TWO MACHINES OPERATED BY A SINGLE PANTOGRAPH

This is known as a double power hand-machine. It is embroidering row after row of separate figures.



CLOSE UP OF THE FRONT OF A SCHIFFLI MACHINE

Part of the controlling mechanism of the automat is shown in the foreground of the photograph.

sampler of just how the pattern will look when reproduced by a schiffli machine through the agency of the automat. Plainly, much of the ultimate effect depends upon how the experts in this department interpret the artists' designs in a succession of seemingly meaningless holes. These men are highly paid; and our native manufacturers have mustered to their services some of the best of these specialists—drawing without stint from the embroidery centers of Europe.

When a schiffli machine is controlled by pantograph, the operator stands at the left of the apparatus, and in front of him, tacked to a vertical board, is a drawing like that supplied the automat card-maker. The pantograph man guides the pointer of his lever over the enlarged pattern before him, and the machine, running the while at a speed which he can regulate, reproduces stitches in accordance with the movement of the arm, but upon a scale of only one-sixth that of the design. Although the needles function mechanically and in the same manner as the automat-controlled schiffli, nevertheless the resultant product has a more pleasing effect, because to a degree the operator is able to bring out his design with a measure of freedom. He can lengthen his stitches or he can shorten them by the travel of his pantograph, and, similarly, he can "build up" the reproduced pattern—thus lessening the flat and precise look of the entirely machine-made goods. This method of operation is employed in the decorating of the finer textiles, such as organdies, batistes, etc.

As may be readily imagined, the functioning of the shuttle or schiffli apparatus requires the winding of hundreds of spools and bobbins. The filling of the latter is especially interesting; and exceedingly ingenious machines do this work at a rate that makes it possible to keep the embroideries supplied. They are so arranged that they wind upon inch-long spindles the exact amount of thread desired, cut the thread, and then toss the bobbins into boxes. These, according to the ply of the thread, are delivered to the schiffli machines, where the shuttle girls draw upon them as occasion requires. The duty of the shuttle girl is to see that the shuttles are filled. The watcher at the front of the apparatus keeps his eye on the work and detects promptly any lacking stitches due to a breaking thread or an exhausted spool. Rethreading is the work of an instant. Wherever a needle has failed to embroider, the imperfection is subsequently marked by inspectors and the blank spaces stitched in by experts on regular sewing machines.

Perhaps the most interesting work is that or the American power-driven hand machines. These do their work in much the same manner as the hand machines so extensively employed in the St. Gall district of Switzerland, but they are capable of turning out a much larger quantity of decorated fabric in a given time. They are unique in the industry, and typify the American desire to build up a domestic manufacture of the very finest grades of goods such as hitherto have reached us exclusively from abroad. In these machines we have in effect mechanically duplicated the action of a needlewoman as she works her thread back and forth through her material. As has already been explained, the stitch of the hand machine is radically different from that of the schiffli, and no shuttles are needed.

That needles used are pointed at both ends, with the eye in the middle, and through the latter is threaded just enough yarn to embroider a given repeat. The operative mechanisms on both sides of the cloth are identical and function alike, but alternately. For the sake of simplicity let us deal with but a single strip of the material in the two-story machine. The needles on the starting side are held in spring clips spaced equi-distant horizontally, and these clips, in their turn, are supported by a frame which advances and retreats in relation to the vertically disposed textile. When the frame goes forward it pushes all the needles through the material and, at the right instant, opposing clips grasp them and pull them, with their attached thread, completely through—the initial clips releasing their hold. A moment later, hooks reach up

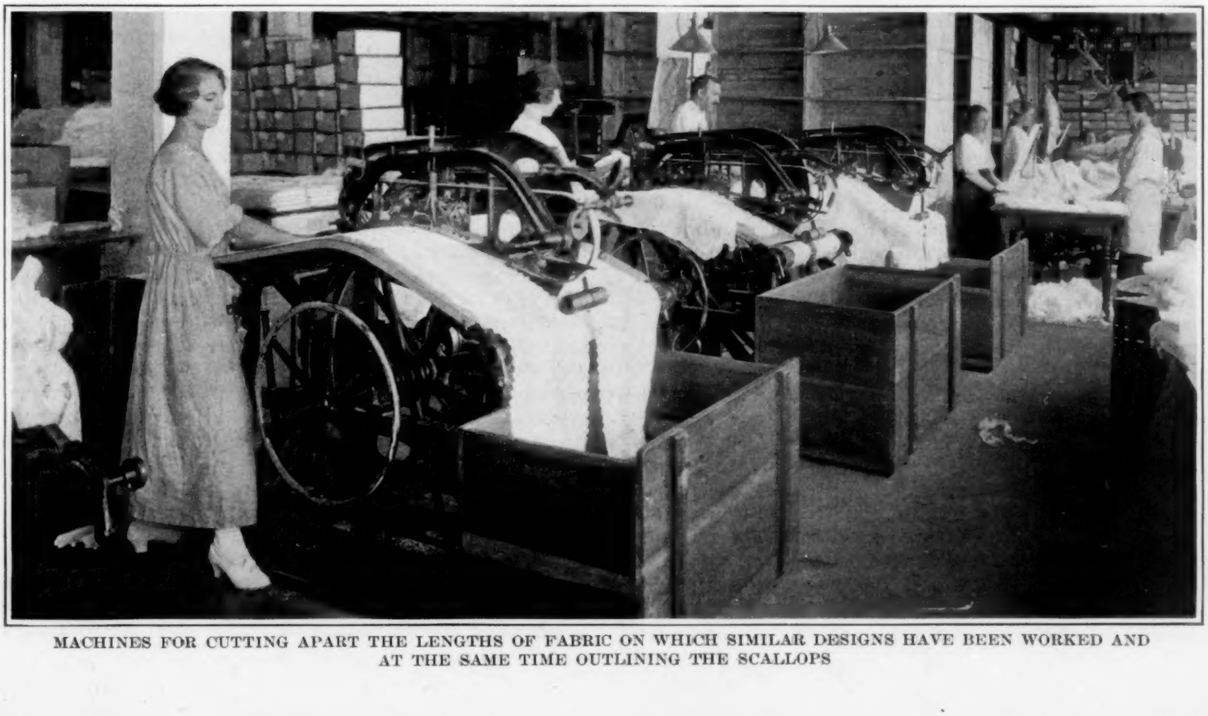
MACHINES (ON THE LEFT) WINDING BOBBINS FOR THE SHUTTLES OF SCHIFFLI MACHINES AND (ON THE RIGHT) WINDING THREAD UPON SPOOLS TO FEED THE SCHIFFLI NEEDLES

EMBROIDERIES BEING EXAMINED FOR IMPERFECTIONS ON THE STRETCHING TABLES. WOMEN EXPERTS FILL IN ON THE SEWING MACHINE WHERE THE EMBROIDERY MACHINE FAILED TO WORK

and pull down upon the following yarn, and in this way draw the stitch into place. By recourse to these hooks the horizontal travel of the carriage is held within narrow limits. It must be plain that the needles are passed to and fro successively, the vis-a-vis clips taking turns in pushing and pulling them in and out of the cloth, thus duplicating the design on the two sides of the fabric.

The stitcher, who controls the movement of the textile to be embroidered, does this by means of the pantographic attachment, and he times the shifting of his pointer to synchronize with the speed of the needle-guiding frames. The product from these machines is of a superior grade, and the embroidery is done upon expensive fabrics of wool, silk, linen and cotton. These machines do eyelet or open work, scalloping, etc., just like the schiffli apparatus. As might be expected, the needles have to be frequently rethreaded, and for this service there has been invented a very interesting little machine which automatically threads quite 25,000 needles daily. It functions as though inspired by human intelligence. The needles are dropped in a hopper from which, one by one, they roll down upon a plate halting with the eye vertical. This is made possible by flattening the surfaces at the eye portals so that the needle can come to a standstill on either of two sides. Immediately after coming to rest, a thin knife blade descends into the eye steadying the needle, and then shoves it along a short distance where a clip grips one point. The knife blade is next withdrawn, and immediately afterwards a hook enters the eye, catches the yarn and threads the needle on retreating. Following this the machine knots the yarn, cuts the thread the requisite length, and finally sticks the needle into a strip-like cushion. They are there assembled in a row with their threads hanging straight down and are ready to be transferred to the clips of the power hand machine.

After the decorated textiles are removed from the machines, they are sent to inspecting rooms, where they are pinned on long tables and all "floating" threads are skilfully removed



MACHINES FOR CUTTING APART THE LENGTHS OF FABRIC ON WHICH SIMILAR DESIGNS HAVE BEEN WORKED AND AT THE SAME TIME OUTLINING THE SCALLOPS

by clippers. Next, the goods are carefully inspected and marked wherever defective. The needful "mending" is done by operatives especially trained for the work. In the case of cotton fabrics which are embroidered before the textiles are bleached, the goods are sent, after being repaired, to be bleached; and the manner in which this is done has much to do with the appearance of the merchandise as the public knows them.

Probably no branch of the machine-made embroidery industry is more typical of inventive cunning than that of making so-called "burnt-out" lace, in which the same apparatus serves to do the stitching. Imitation filet, Venetian point, etc., can be produced in a manner that will deceive any but the practised eye. Here is where we see Tuton resourcefulness once more in the realm of adaptation. Thirty-nine years ago a German of the name of Bickel originated at Plauen the process of embroidering on tulle, and from this idea of working upon a net base followed the practice of embroidering on a material which could be removed chemically so as to leave only the lacy stitching. Plauen laces have won a world-wide reputation, and they are fashioned on schiffli machines. When the fabric to be removed chemically is of vegetable fiber, the embroidery thread is of animal fiber, and if the material to be destroyed is of animal origin then the lace is formed of a thread of vegetable substance. For example, if lace is of cotton the foundation textile is of wool, as a rule, while silk embroideries are stitched upon cotton chemically treated to facilitate its removal. The foundation fabric, according to its nature and preparation, can be done away with either by a chemical bath or the application of moderate heat. Where heat is the destructive agency, a temperature of 180 degrees Fahrenheit will answer. This renders the supporting goods brittle so that it will break up and disappear as a powder when brushed. A very large part of the machine-made laces worn by women are manufactured in this way; and this fact exemplifies the flexibility of performance of the embroidery machine.

In 1890 we imported from Switzerland embroideries and laces to the value of $7,247,952; in 1900 the business was valued at $7,389,924; but six years later the Swiss sold to us goods of this kind to the amount of $15,981,168. From that time on until 1913 the United States purchased the largest share of the Swiss annual production, ranging in the neighborhood of $40,000,000. The war curtailed the consignments to this country. It is not to be wondered at, then, that some of our own people determined to develop a kindred industry here, and between 1890 and 1906 embroidery plants were established in various States, principally New York and New Jersey, with a total of 616 machines. Today our factories are of much larger capacity, and the business has been greatly stimulated by our efforts in the last four or five years. In some kinds of goods we are in a position to compete with the foreign products, despite the cheaper labor and operative costs abroad; and in a general way it may be said that the industry is a growing one in this country, and the people interested are doing everything possible to advance it. Incidentally, they are forming instructional centers where skilled labor can be trained to meet the different needs of the craft.

# Eye Protection in Welding Operations

## Search for a Transparent Material That Will Exclude Infra-Red and Ultra-Violet Rays

### By C. Sylvester, A.M.I.E.E., A.M.I. Mech. E. (London)

THE art of electric welding has greatly improved during the past few years. So much so that one can hardly realize that only a few years ago we were almost afraid to handle electricity from a welding point of view beyond the old annealing plant stage.

It is very pleasing to observe that, with the development of electric arc welding, there have also been satisfactory recent improvements in the design of the masks and helmets used by the operators. That these improvements were necessary there was not the slightest doubt because the old type of helmet was not only heavy and cumbersome but it was extremely uncomfortable to wear. I have seen welding operators throw them off in disgust at their uncomfort, quite a justifiable proceeding, as was their poor workmanship. This can be realized when it is considered that good workmanship could hardly be expected from men who had to work under such uncomfortable conditions. Hence, the advent of the light, comfortable helmet was welcomed.

Although some portions of the equipment used for efficient arc welding have been improved upon, there is room for great improvement in other portions of very essential equipment. The most important of these items, perhaps, is in connection with the glasses used for the protection of the eyes.

This is a problem for the inventor, one well versed in physics, and the task he is set to accomplish is to provide a perfectly safe filter which will permit of the greatest degree of visibility, yet will exclude the infra-red, or heat rays, and the ultra-violet rays. Ordinary glass lenses are usually sufficient to protect the operator against the latter radiations, but to protect him against the heat rays glasses of a special color, or a combination of colors, are required.

Before one can deal with this subject from an inventive point of view, it is necessary that the liquefaction of metals through the effects of heat, the gases delivered from these molten metals, and the effect of these gases upon light, should be thoroughly understood. Dealing briefly with these, it may be considered that radiation from an intensely heated metal is divided under three headings:

1. Invisible infra-red rays.
2. Visible light rays.
3. Invisible ultra-violet rays.

It may be said that these divisions merge into each other so that there is no definite line of demarcation between them.

These radiations are not uncommon, that is, they are to be met with almost anywhere, and under almost any conditions. If one is abroad, say in Malta or Jamaica, the glare of the sun upon the white buildings and streets has an effect upon our eyes which is not very pleasant. Again, we remember how in France the continual looking at the arc of a searchlight, even though this was done through a ruby glass, sometimes affected not only our eyes but our heads. Even at home, in our own drawing rooms, the incandescent lamps have to be fixed in such positions that we can obtain a maximum amount of light with a minimum amount of discomfort. One could continue to discourse upon this subject, but it would not alter the fact that the radiation referred to above produces very diverse effects upon our senses. Thus the infra-red rays produce the sensation of heat when they fall upon our unprotected skin, although the rays are invisible to the eyes, yet the ultra-violet rays are not manifest by our senses, but are quite clear to us by their effects.

The very intense glare which is emitted from between the electrode and the metal in an arc welding process is a combination of rays, and special devices have to be adopted to protect the operator from their harmful effects. The precautions which are necessary in each case depend upon the actual job or size of weld. Thus, for light welding, it would only be necessary to protect the eyes with suitable colored glasses

fitted in a convenient form of goggles. For heavy electric welding, which requires the use of both hands, the operator protects his eyes and neck with a helmet which rests upon his shoulders to relieve the strain upon his head. This helmet is fitted with a round or rectangular window of safety glass.

To be able to state with certainty the color or combination of colors necessary for the eye protection, it is necessary that the hues of the prismatic spectrum should be understood. By the term "prismatic spectrum" it is meant the spectrum of a heated solid mass. Here the spectrum is visible in the shape of a continuous band which varies in color from one edge to the other from red and orange, to yellow and green, to blue and violet, until, on the extreme edge, it fades to ultra-violet.

When this solid mass is subjected to intense heat, such as when the metal commences to melt in an arc welding process, the spectrum is divided up or crossed with lines which make a certain amount of it disappear. The chief effect of this is that the red and orange almost disappear, the yellow and green are much less but are slightly more prominent than the red and orange until, on the other edge, the blue and violet is more intense and the ultra-violet is much deeper than in the spectrum of the solid mass. The reason for these lines is that the liquefaction of iron through the medium of electricity, produces elements, principally carbon, nitrogen and oxygen, which are unavoidable components of the electric spark discharge. It is these elements which affect the characteristics of the visible light emitted by intensely heated iron vapor during the process of electric arc welding.

The problem of supplying a satisfactory safety glass is not a new one by any means and at the present moment there are many different kinds of safety glasses on the market. There are also many combinations of colored glass in common use, the merits of which are open to be questioned. The fact remains, however, to obtain a perfect safety glass the merits and demerits of even colored glasses must be considered. Under these circumstances it will not be time wasted if we devote a little time to this subject.

It is comparatively well known that the average human eye shows a certain amount of chromatic aberration towards the red, and blue or violet ends of the spectrum. This is not so as far as the middle colors are concerned. From this it will be seen that a much clearer definition of an object is obtained by certain combinations of yellow-green light than by red or by blue or violet light alone. It may also be said that the eye is much more sensitive to yellow and green rays than it is to red or blue or, in other words, yellow green light has the greatest luminous efficiency. To substantiate this one has only to consider for a moment the efficiency of the mercury vapor lamp for certain purposes. Or it may be easily tested in the home by looking at fleecy clouds through pieces of different colored glass. A yellow glass, or amber, will bring out details that are hardly observable without the glass, yet which will be totally obscured if tried through a blue or violet glass. From this it will be gathered that to obtain the greatest amount of visibility with the least amount of glare, the essential elements of a perfect safety glass, the color tint should be decided by an expert, in conjunction with the man who is going to use the glass. In addition to this, the size and shape of the glass should be taken into consideration since the number of rays will be in proportion to the area of the glass.

Referring to the view of a spectrum through different colored glasses it can be understood that a piece of colorless glass will transmit the whole of the colors from edge to edge. A ruby glass will transmit the red and orange rays with a very slight trace of yellow, but the whole of the other colors are entirely cut out. A special kind of yellow glass will decrease the amount of red and will entirely cut out the blue and violet, yet, on the other hand, it will bring out the orange and yellow. Emerald-green will transmit the whole of the yellow and green. The red, orange and blue, however, will not be quite so prominent.

Experiments recently carried out prove that cobalt glass is more transparent than clear glass to the ultra-violet rays under certain conditions. In these experiments clear and blue glasses (soda lead) were used. They were of equal thickness and of the same content with the exception that the blue glass contained a very small percentage of cobalt. Clear and blue specimens of the same thicknesses were compared in pairs by photographing the spectrum of:

1. A quartz mercury arc.
2. Sunlight.
3. The iron arc through an arc welding plant.

Various thicknesses were studied, but the thickness of each pair of glasses were indentical with each photographic exposure. The experiments established the fact that, under certain conditions, the glass containing the slight amount of cobalt was more transparent. Hence, for arc welding safety glasses, the addition of a slight amount of cobalt may be of practical advantage in certain cases.

After considering the best means of toning down the flickering and glaring light which is produced during the arc welding process, a certain amount of consideration may be given to the infra-red and ultra-violet rays which are inseparable from the visible glare. In the first place it should be remembered that when the invisible infra-red rays encounter some material which they cannot penetrate they immediately become absorbed and are changed into heat. This is why they are sometimes termed heat rays. It is most essential that the eyes should be protected from these rays, and although the colored glasses previously referred to will absorb a certain amount of this heat they are not sufficient under some conditions, such as welding a heavy stud into a steel plate when an enormous amount of heat would be required.

There is no difficulty in finding a material which will absorb a large quantity of these heat rays. The difficulty is in finding the most efficient material which will absorb these rays yet will give us the greatest amount of visibility. Clear white mica will absorb a small percentage of these rays, and the sight on the weld is not impaired to such an extent that it will be dangerous. On the other hand, dark mica will absorb a large quantity of these rays, according to its thickness, yet the vision will be so impaired as to make efficient welding a practical impossibility.

A pale green glass of a certain thickness appears to be the most satisfactory at present. This will transmit about 65 per cent of visible light yet, at the same time, it will absorb about 90 per cent of the heat rays. In England we have a reflector for our high candle power incandescent lamps which is composed of two different kinds of glasses. The under portion of this reflector is of opal glass, the upper portion is of pale green. It is very pleasant to the eyes. Owing to the opal composition of the under portion of the glass it is not transparent, but experiments with this combination of glasses may produce something which may be of service to the arc welding operator.

One must not think that because an optician can supply a certain quality of material for defective eyesight that this material will be a protection against the dangerous ultra-violet rays. This is not so. We will take, for instance, the material with which the majority of spectacles and other such apparatus are made. These are made from quartz or natural rock crystal, sometimes termed "pebble." Pebble is transparent to the ultra-violet rays and therefore offers no protection against their seriously harmful features. On the other hand, ordinary clear glass does offer a certain amount of protection but not so much as amber or yellow-green glass.

It has already been pointed out that in this selection of glass the operator himself should be considered. No two men have two sights alike, and, therefore, it may be necessary to go to a little expense and trouble to obtain the correct color of glass for a particular operator. This expense, however, will be nothing compared with a better quality of work, a more contented operator and all-round efficiency.

# Deep Etching of Steel*

## Metallographic Features Revealed by the Use of Acids of Relatively High Concentration

By Henry S. Rawdon and Samuel Epstein

THE term "deep etching," as used here, refers to the use of acids of relatively high concentration for the roughening of the surface of metallographic specimens. Samples etched in this manner are intended primarily for a study of the macroscopic structure rather than for microscopic examination. In general, a very mild etching reagent is required for the latter purpose. The deep etching of steel is one of the earliest metallographic methods used for the study of iron and steel, particularly for a quick shop test. The method has, however, been given prominence recently by its application to the study of rails containing the defects known as transverse fissures and of steel forgings containing similar defects.[1]

Various views have been put forth as to the nature of the features revealed by this method of etching. The interpretations of the features revealed in transverse fissured rails by this method of etching may be cited as typical of the difference of opinion existing. That a variation in solubility of the steel in different directions is responsible for the transverse "cracks" revealed by the etchng is one extreme view held. The other extreme is that cracks exist throughout the interior previously to the etching and that the etching merely renders them visible. According to still another view, the existence of internal stresses of a rather high magnitude may be responsible for the results produced. In order to show clearly the various conditions which this method of etching will reveal, together with the description of suitable methods for distinguishing between the different features, the series of examinations described below was undertaken.

In the work described below hydrochloric acid (specific gravity, 1.19) was used; this was heated nearly to 100°C. before the specimens which had been previously ground smooth were immersed. Heating, however, should not be regarded as a necessity—it merely hastens the action.

### FEATURES REVEALED BY DEEP ETCHING.

1. *Chemical Inhomogeneity.*—The use of acid etching for the purpose of revealing variations in the distribution of the various chemical constituents which may occur in steel is so well known as to require only a brief discussion. The variations in the chemical composition are usually the direct result of the segregation accompanying solidification, although occasionally other factors may be responsible; for example, lack of complete solution and diffusion of the special additions in alloy steels, composition changes which may occur in such processes as welding, carburization, etc.

Fig. 1 illustrates the case of chemical inhomogeneity due to segregation. The bar evidently has been rolled from an ingot having a decidedly segregated center; the difference in composition between center and outer portions has persisted throughout the process of rolling.

The greater solubility of the abundant sulphide streaks in the central portion as compared to the purer metal is responsible for the roughened appearance of the center. Each dark spot (Fig. 1) represents a pit which was previously occupied by sulphide or some other inclusion. These pits are later deepened and enlarged by the action of the acid after the inclosed impurity has been removed.

Fig. 3. illustrates a condition which has resulted from what may be termed "secondary segregation." The photograph shows a section of a large steel casting which, although it met the prescribed specifications as to mechanical properties and heat treatment, fractured as a result of the handling received during transportation.

The macroscopic examination of the material after deep

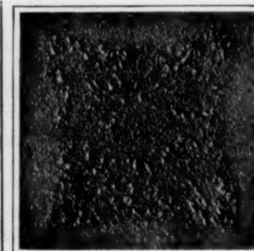


FIG. 1. CHEMICAL INHOMOGENEITY OF ROLLED STEEL REVEALED BY DEEP ETCHING. × 2.

FIG. 2. POROUS CONDITION OF CAST STEEL

Same as Fig. 3, heat treated. Spots due to exudation of alcohol and water used for washing, indicate spongy areas. × 30.

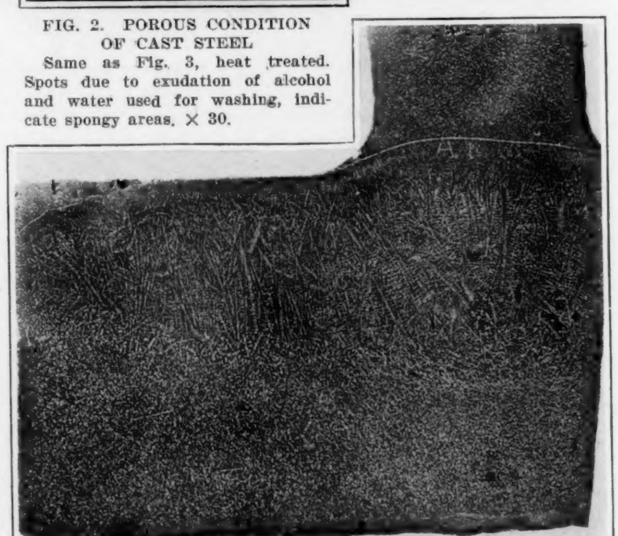


FIG. 3. CHEMICAL INHOMOGENEITY OF CAST STEEL REVEALED BY DEEP ETCHING

Although the casting was annealed for 72 hours at 900 deg. cent. the original dendritic pattern persists. × 2/5.

etching, together with the subsequent study of the microstructure, showed that although a sufficient grain refinement had been brought about by the annealing which the material had received (72 hours at 900°C (1650°F.), cooled in furnace) the material still possessed essentially the same dendritic structure that resulted upon casting. This was due to secondary segregation or the occurrence of numerous inclusions between the treelike crystals. Such impurities are not materially changed by heat treatment either in location or chemical composition and hence the original appearance, and many of the

*Abridged from Technological Paper No. 156 of the Bureau of Standards.

[1]F. M. Waring and K. E. Hofammann, The Deep Etching of Rails and Forgings, A. S. T. M. Proceedings, 19, 1919; also discussion on the same. H. M. Wickhorst, Transverse Fissure Rails on Atchison, Topeka & Santa Fe R. R., heat 411177, report No. 80 to rail committee, Am. Ry. Eng. Assn., April, 1919. P. H. Dudley, Report on Transverse Fissures, report No. 77 to rail committee, Am. Ry. Eng. Assn., January, 1919. H. Baucke, Action of Electrolytes upon Metals under Stress, Int. Zeit. für Metallographie, 4, p. 129; also Proc. Int. Assn. Test Materials, VIth Congress, 1912.

accompanying mechanical properties, are maintained in spite of the annealing. The microscopic examination showed also that in addition to the inclosures trapped between the fingers of the dendrites, the metal was also porous and spongy at such points. This is shown in Fig. 2. The specimen was polished and cleaned as for microscopic examination but was heat tinted to reveal the structure instead of being etched. The water and alcohol used for washing and drying the surface were absorbed at each porous spot and oozed out upon heating, thus preventing a uniform oxide tint from forming at such spots. The action of the deep etching upon the material shown in Fig. 3 has consisted essentially, then, in the relatively more rapid dissolving of the impurities and in the enlarging of the pores of the spongy areas. In addition to these features, Fig. 3 also illustrates what may be found in welded materials etched in this manner. The projection or boss in the upper portion of the figure was added after the main casting had been made. The white (deeply etched) line marks the junction surface between the two.

a

b

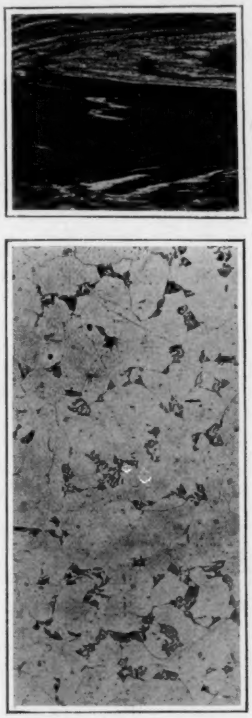


FIG. 4. CHEMICAL INHOMOGENEITY OF COMMERCIAL WROUGHT IRON

a

b

FIG. 5. CHEMICAL INHOMOGENEITY OF SWEDISH WROUGHT IRON

*Above*, polished specimens deeply etched in concentrated hydrochloric acid. × 1. *Below*, microstructure of white bands shown above. × 100.

A special application of the use of deep etching in the inspection of wrought iron is illustrated by Figs. 4 and 5. Wrought iron when ground smooth or filed and then etched with concentrated acid,[2] shows the presence of steel streaks by the white glistening appearance of such streaks; the body of the wrought iron remains dark. Fig. 4, *a*, shows the appearance of a large commercial wrought-iron shackle which was examined to determine its purity. The white streaks are of steel and have the structure shown by Fig. 4, *b*.

Fig. 5 shows the results of a similar examination of a bar of high-grade Swedish iron. The light streaks are of steel of a composition approaching that of eutectoid steel.

2. *Mechanical Nonuniformity.*—It is quite often the case that metals, even when subjected to no service load or stress, are far from being in a state of mechanical uniformity. Internal initial stresses of considerable magnitude often exist, particularly if the material has been cold worked. Very sudden or unequal cooling of different parts of the same piece may give rise to a similar condition. Considerable work has been done on this subject as related to brass and bronzes, and materials of this kind highly internally stressed may be made to crack spontaneously by the use of proper etching reagents.[3] As yet, but little attention[4] has been paid to the behavior of steels in this respect.

As suitable material for demonstrating the effect of deep etching by concentrated acid upon steels initially stressed internally, commercial balls for ball bearings of different sizes and grades were used. The chemical composition of the specimens used is given in Table 1.

*Table 1.—Chemical Composition of Balls Used.*

| Diameter of ball | Carbon | Manganese | Phosphorus | Sulphur | Silicon | Chromium |
|---|---|---|---|---|---|---|
| | Per cent | Per cent | Per cent | Per cent | Per cent | Per cent |
| 1 inch | 1.05 | 0.32 | 0.013 | 0.030 | 0.15 | 1.28 |
| ½ inch | .94 | .38 | .018 | .022 | 18 | (a) |
| ⅜ inch | 1.25 | .25 | .011 | .016 | .21 | .007 |

As shown in the above table, balls of three different sizes and compositions were used. The appearance of the balls after etching gave rather definite indications as to the method of manufacture. Some of the smallest balls had been turned out by lathe tools, as was clearly shown by the ends of the fibers on the opposite faces of the balls after etching. All of the others showed the two poles and work lines which are evidence of forging and pressing. The 1-inch balls most probably were forged individually; the others by the string method.

Previous to etching, the balls were examined for the presence of cracks or other surface defects by the magnetic method to be described later. None of the specimens was found to be defective. The behavior of the balls when etched with hot concentrated hydrochloric acid was determined for the material in the commercial state; that is, as received and

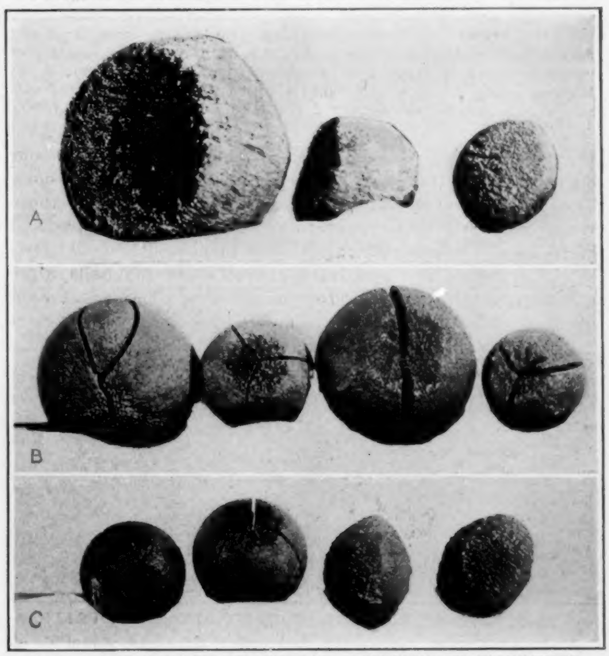



FIG. 6. PRESENCE OF INITIAL STRESSES IN HARDENED STEEL REVEALED BY DEEP ETCHING. × 2.

(*A*) Fragments of balls that did not split after prolonged etching. (*B*) Balls which split as a consequence of internal stresses due to forging or pressing. (*C*) Two balls at the right were turned out and the other two were forged or pressed.

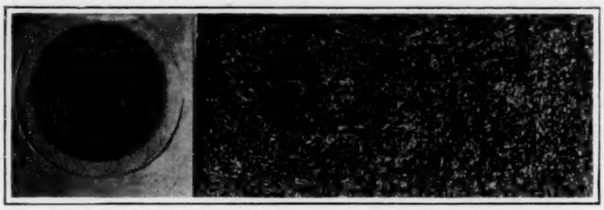
[2]Steel in Wrought Iron Pipe, *Iron Age*, 97; p. 1132; 1916.

[3]B. S. Tech. Papers, Nos. 82, 83, and 84. The technical literature of the subject is summarized in No. 82.

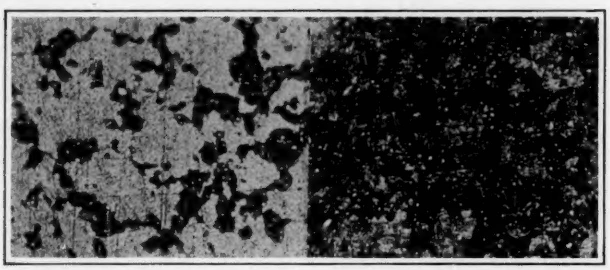
[4]Baucke, loc. cit.

also after different heat treatments. Some of the specimens were also sectioned in half, some perpendicular, and others parallel to the direction of the fibers.

None of the large (1-inch diameter) balls showed any tendency to split upon deep etching, as did over 50 per cent of



*a* *b*



*c* *d*

FIG. 7. STRUCTURE OF HARDENED STEEL BALLS

(a) Hardened ball of 1-in. diam. cut through center and polished. × 1. (b) Microstructure of outer spherical layer (light-colored) of (a). The layer is martensitic throughout with tiny globules of cementite. × 500. (c) Intermediate thin zone between outer layer and dark-colored central sphere of (a). This transition zone consists of martensite and troostite with some specks of carbide × 500. (d) Microstructure of the central sphere of (a). None of balls of this size split. Etching throughout 2 per cent alcoholic nitric acid.

the medium-sized (one-half-inch diameter) balls and about 30 per cent of the small (three-eighths-inch diameter) ones. The small ones which split were limited entirely to those which, as shown by the appearance of the etched surface, had been forged (or pressed) rather than turned out.

Fig. 6 shows the appearance of some of the balls after etching. The specimens were removed from the acid as soon as the cracks appeared, hence before the openings had been

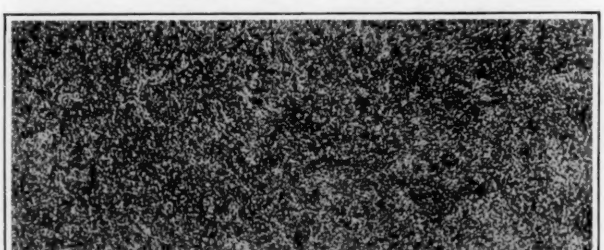


FIG. 8. MICROSTRUCTURE OF HARDENED STEEL BALLS

These balls were martensitic throughout. Structure typical of specimens which split when deeply etched. ×500.

widened appreciably by the acid. In all cases the cracks are very definite ones, resembling knife cuts extending through the poles and often reaching in as far as the center of the ball. They follow somewhat the direction of the fibers of the material. Without doubt the splitting of the balls under the corrosive action of the concentrated acid is to be attributed to the presence of initial stresses of relatively high magnitude in the material. It was not possible, on account of the nature of the material, however, to attempt any measurement of the approximate value or distribution of such stresses. The sudden appearance of the cracks, the immediate widening of the fissure with an appreciable accompanying increase in the diameter of the ball, the occurrence of such cracks only in the forged or pressed material and in the smaller balls which had been hardened entirely throughout, the failure of all the materials to split when hardened less severely than the commercial material, and the definite orientation of the cracks with respect to the poles of the balls all are lines of evidence indicating the presence of internal stresses as the cause of the behavior of the balls upon deep etching. Baucke[5] in his discussion of experiments along this line states that it is necessary to section the balls before etching, and that whole balls etched intact will not split. In order to demonstrate whether the tendency of sectioned balls to split upon etching is greater than that of whole balls, a series of specimens were sectioned. In general, the tendency to split upon etching appeared to be less for the sectioned balls than for the whole ones. It is very probable that the stresses within the material are materially relieved by cutting the ball in two, and hence they would be expected to show less tendency to split in the acid.

The method used for sectioning the hardened balls is of interest. A cylindrical hole very slightly smaller across than the diameter of the ball was drilled into a block of soft steel to a depth slightly greater than the radius. The ball was pressed into the hole by squeezing in a vise and the portion projecting beyond the face of the steel block was ground off on a wet grinding wheel. No evidence of tempering of the balls during grinding could be observed in the polished specimen.

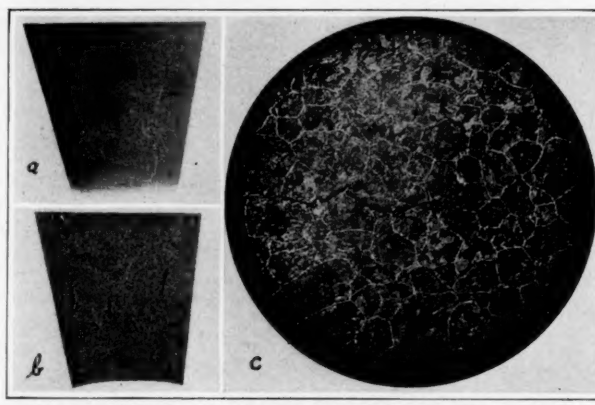



FIG. 9. DEFECTS IN GUN FORGINGS REVEALED BY DEEP ETCHING

(a) Transverse radial section gun tube polished to show interior defects. × 7/8. (b) Specimen (a) after deep etching in concentrated hydrochloric acid. Defects greatly widened and deepened. × 7/8. (c) Cross section of 1-in. "round" trepanned out of large bloom intended for gun tube, etched with 2 per cent alcoholic nitric acid. Crack undoubtedly of same origin as defects in (a), probably originating at rather high temperature. It is largely intercrystalline in its course. × 2½.

Fig. 7 shows the structure of the large (1-inch diameter) balls. The outer metal has been rendered martensitic to the depth shown in Fig. 7, *a*. The central portion is largely troostitic. In Fig. 8 the structure typical of the small and the medium sized balls is shown.

These specimens were martensitic throughout. This difference in microstructure is in accordance with the results of the etching tests—only the severely hardened specimens showed any tendency to split upon deep etching. It will be noted in Table 1 that the balls of one-half inch diameter are of steel containing no alloying element and of a carbon content considerably lower than that of either of the other two. In order to render this steel relatively as hard as the other two types, a much more severe treatment must be resorted to, and this fact probably accounts largely for the greater tendency of this series to split than the other two. That the mechanical work which the material received (i.e., the magnitude of the internal stresses) also contributes to the tendency to split is evident in

[5] Loc. cit.

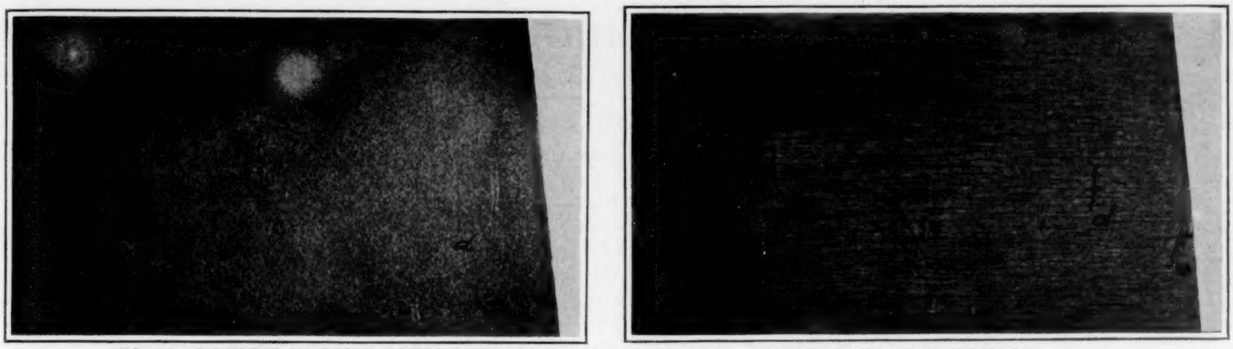


FIG. 10. DEFECTS IN RAILS CONTAINING TRANSVERSE FISSURES REVEALED BY DEEP ETCHING

The right hand view shows longitudinal section of head of rail No 3 (Table 2) parallel to tread. Speciment magnetized and then immersed in kerosene containing iron dust in suspension. Cracks indicated by *a*, *b*, *c*, *d*, and *e* were located. Left hand view shows same specimen deeply etched with concentrated hydrochloric acid, revealing cracks more clearly. ×1.

view of the fact that balls of similar size and hardness (i.e., as indicated by the structure) turned out in the lathe rather than forged or pressed showed no tendency to split upon etching.

3. *Physical Discontinuities.*—A third condition which may be revealed by deep etching is the presence of discontinuities within the steel. These may be in the form of pores or tiny cavities whereby the metal is rendered spongy, as previously described, or as separations or fissures, the two faces of which are often in such intimate contact that the defects can be definitely located only by special methods and with great care. Two types of materials characteristic of the second condition are flaky gun steel and rails containing transverse fissures.

In Fig. 9 is shown the appearance of a specimen of a defective gun forging (composition: Carbon 0.38 per cent, chromium 0.20 per cent, nickel 2.92 per cent) in which the defects are quite readily detected after polishing. Deep etching accentuates these by widening and deepening the fissures.

Fig. 9, *c*. shows the appearance of a section of a 1-inch round trepanned out of a large bloom of gun steel similar to that of the forging of Fig. 9, *a*, suspected of being defective. Subsequent deep etching revealed the cracks shown in Fig. 9, *c*. Presumably the cracks here revealed are identical with the defects found in the finished forging (Fig. 9, *a* and *b*). It will be noted that the crack is intercrystalline for the greater part of its course.

Defects similar in appearance to those just described have been found in abundance in rails containing transverse fissures, by means of deep etching.[6] In this case, however, the presence of the defects, gashes or cracks, in the material previous to etching has never been demonstrated. Hence there have resulted considerable differences of opinion as to the significance of the results obtained by the deep etching of transversely fissured rails. As materials typical of this type of defect, specimens were taken from three different rails which had developed transverse fissures in service. The compositions of the three, which differed widely in this respect, are listed in Table 2.

*Table 2.—Composition of Rails Containing Transverse Fissures.*

| Rail No. | Carbon | Manganese | Phosphorus | Sulphur | Silicon | Chromium | Nickel |
|---|---|---|---|---|---|---|---|
| | Per cent | Per cent | Per cent | Per cent | Per cent | Per cent | Per cent |
| 1. | 0.63 | 0.71 | 0.014 | 0.022 | 0.09 | 0.50 | 1.89 |
| 2. | .62 | .91 | .020 | .036 | .01 | (*a*) | (*a*) |
| 3. | .90 | 1.22 | .094 | .022 | .14 | (*a*) | (*a*) |

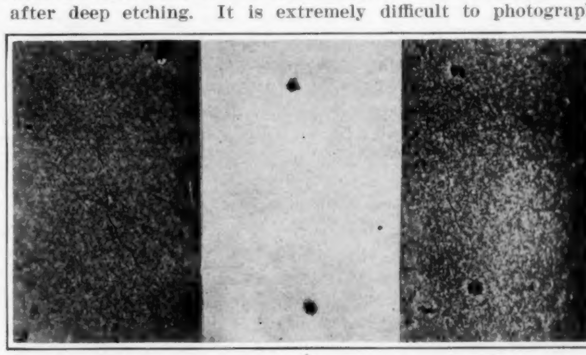
*a* not detected

Portions of the head of each of the three rails were cut parallel to the tread into a series of slices. Each of the slices, after grinding, was etched to demonstrate the presence of gashes of transverse cracks. In each case these were found in abundance in the central and lower portions of the head, as has been shown by previous investigators.

[6]Waring and Hofammann, loc. cit. Wickhorst, loc. cit.

It is extremely difficult, however, to demonstrate by ordinary metallographic methods the presence of these defects within the material before the deep etching. Radiographic examination of thin slices (one-quarter inch thick) proved to be ineffective as a means for locating them. The only method by which the cracks could be located, without etching the specimen, was a magnetic one. This method was finally adopted for the preliminary examination of all the specimens suspected of containing cracks of any kind. The sample, which must be well polished, as for microscopic examination, is magnetized and then immersed in kerosene, or a similar liquid, containing *very* fine iron dust in suspension. "Cast-iron mud" from disks used for lapping was used for the purpose. The particles of iron dust collect upon the face of the specimen, and at the points where, because of a discontinuity in the metal, a change in the density of the magnetic flux occurs, orient themselves to correspond to the shape of the discontinuity. The specimens are then washed in clean kerosene to remove as much as possible of the excess iron dust which clings to the surface.[7]

In Fig. 10 is shown the appearance of a slice from the lower part of the head of the rail No. 3, which has been treated with the iron dust after magnetizing and the same specimen after deep etching. It is extremely difficult to photograph



*a* *b* *c*

FIG. 11. INTERIOR CRACKS EXISTING IN RAILS OF THE TRANSVERSE-FISSURE TYPE. × 3.

(a) Crack *b* of Fig. 10 viewed obliquely. (b) Same specimen with line of crack located by punch mark at each end and iron dust wiped off. No crack visible. (c) Speciment (b) treated a second time with iron dust. Compare with (a).

the specimen so as clearly to show the results of the treatment with iron dust. They are much more readily seen upon visual examination than might be inferred from the photograph. Comparison of the two views in Fig. 10 shows the presence of a very fine crack or discontinuity in the unetched specimen corresponding to each of those revealed by deep etching.

[7]This method for the examination of polished surfaces suspected of containing surface cracks was developed at the Bureau for the inspection of precision gages.

The appearance of the cracks located by the magnetic method is more clearly shown in Fig. 11, somewhat magnified, in which the surface was viewed obliquely. Crack *b* (Fig. 10) was located by means of iron dust after magnetizing the specimen. Its position was then recorded by punch marks at each end of the crack. Fig. 11 (*b*), shows the specimen after the iron dust was wiped off; no crack can be detected between the punch marks. Fig. 11 (*c*), shows the same specimen after a second treatment with iron dust.

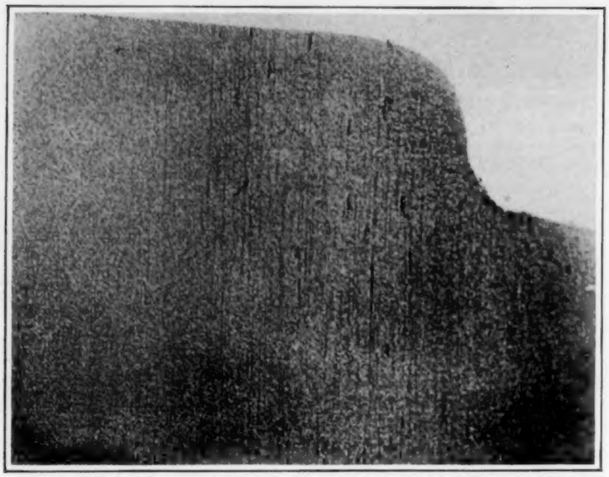


FIG. 12. LONGITUDINAL SECTION OF RAIL NO. 2. (TABLE 2) PARALLEL TO THE TREAD. × 1 3/8.
Interior cracks as they appear after slight etching.

Although it is known with certainty that a discontinuity exists in the metal between the two punch marks, it is extremely difficult to find evidence of it in the microstructure even after light etching.

Fig. 12 shows a section of rail No. 2 after slight etching with concentrated hydrochloric acid. The interior cracks having been widened by the concentrated acid, the surface was ground down, repolished, and re-etched for microscopic examination. In Fig. 13 (×100), and Fig. 14 (×500), a crack is shown passing through the grains and across the grain boundaries. The cracks are intracrystalline, in their course; that is, the break has occurred *through* the grains rather than *between* them.

### NATURE OF DEFECTS REVEALED IN RAILS CONTAINING TRANSVERSE FISSURES.

The results of the examination given above definitely warrant the conclusion that the defects (gashes, fissures, or cracks), revealed in rails of the transverse fissure type by means of deep etching, exist within the material previously to the etching, as discontinuities within the steel. The function of the acid used for etching is merely to widen and deepen the *pre-existing* cracks. The microscopic appearance of these cracks offers some suggestions as to their origin. The course of the crack is intracrystalline and has the general appearance of a fracture produced in normal material; there is no evidence of inherent weakness at the grain boundaries. An answer to the question as to whether the separation occurred while the metal was cold—that is, in the track—or while hot—that is, in the mill—does not appear to be forthcoming from the evidence offered by the examination of the fractures alone. No definite statement can be made on this point. However, the comparison of internal fractures found in ingots and blooms and hence, in all probability, produced at a rather high temperature (Fig. 9, *c*) with those found in rails which developed transverse fissures in service (Figs. 12 to 14) is very suggestive. The internal cracks shown in Fig. 9, *c*, are of the *inter*crystalline type. In general, this is a characteristic of fractures produced in metals at elevated temperatures. On the other hand, the cracks shown in Fig. 12 are of the *intra*crystalline type, a feature which, in general, is characteristic of fractures produced in metals broken at ordinary temperatures.

### SUMMARY AND CONCLUSIONS.

1. The method of deep etching of steel by means of concentrated acids was examined in detail. The choice of the acid is a matter of minor consideration provided it is concentrated enough to produce a vigorous attack of the metal.

2. The metallographic features of steel revealed by deep etching are of three general types: Chemical inhomogeneity, mechanical nonuniformity, and physical discontinuities.

3. Chemical inhomogeneity, usually the result of segregation, shows itself by a more vigorous roughening and pitting of the "impure" portions. Sulphides and other inclosures are rapidly dissolved and the resulting pits are then deepened and widened.

4. Steel which is not mechanically uniform throughout because of the presence of initial stresses, which may be the result of previous mechanical work or of too vigorous quenching during heat treatment, will split when deeply etched, provided the stresses are of sufficient magnitude. Commercial bearing balls of different types were used to illustrate this feature. It was shown that this tendency to crack upon etching may be eliminated by suitable heat treatment. The behavior of steel, in this respect, is identical with the corrosion cracking of brasses and bronzes.

5. Physical discontinuities, such as internal fractures, etc., which may exist in steel, are revealed by deep etching. The acid serves to widen and deepen these discontinuities within the metal.

6. It has been definitely shown that the gash defects found in abundance in rails in which transverse fissures have developed and in similar materials, are physical discontinuities or internal fractures which exist within the material previously to etching. The etching merely reveals the defect. A magnetic method for locating such defects in the unetched specimens is described. This appears to be the only method for determining the nature of these defects with certainty.

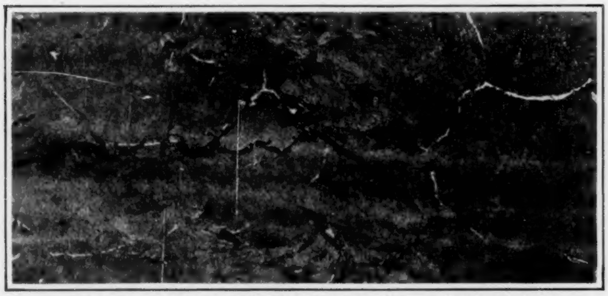


FIG. 13. SPECIMEN SHOWN IN FIG. 12 ENLARGED 100 DIAMETERS
Etched to widen the crack and repolished for microscopic examination.

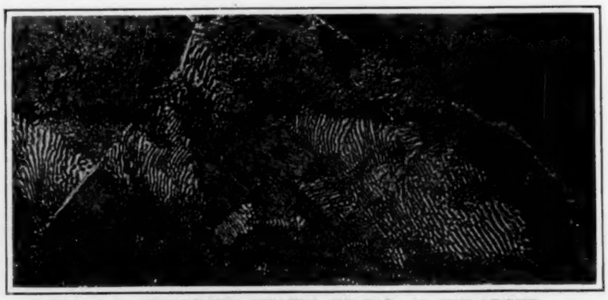


FIG. 14. SPECIMEN SHOWN IN FIG. 12 ENLARGED 500 DIAMETERS
The intercrystaline nature of the crack is here made very evident.

# Steels for Automobile Parts*

## Discussion of the Most Suitable Materials for the Construction of Motor Cars

By Dr. W. H. Hatfield, M.I.A.E.

SEVERAL papers have been written during the last few years dealing with the subject of steels for automobile parts. The general principles have been discussed with considerable effect in these several papers. It is broadly realized that, theoretically, aero and automobile parts should be stressed within their elastic range, but, practically, such ideal design is really impossible for two reasons: In the first place, the stresses which are likely to be put on the different parts of an automobile, for instance, cannot be quite quantitatively predicted, and, in the second place, the designer has not a sufficient knowledge of the elastic ranges of his material. It naturally follows that it is fully realized by the designer that a number of his parts will, in service, almost with certainty be stressed beyond their elastic limit, *i.e.*, some of the parts need to possess a considerable capacity for plastic deformation, or otherwise they will smash. The ideal material for such severely-tried parts is obviously a material with a high elastic range accompanied by the maximum capacity for plastic deformation. Unfortunately, as the elastic range of a steel increases, its ductility decreases, and hence the automobile engineer has to balance in his own mind the relative importance of these two factors in the different parts which are under consideration. It is particularly important in those parts which are likely to receive severe shocks that they shall have this capacity for plastic deformation, particularly so when it is realized that the stresses which are developed under some of those conditions are such that no condition of any steel within the knowledge of the author would have an elastic range high enough safely to carry them.

It is essential that the designer should possess a concrete knowledge of the capacity of his different materials for dealing with the conditions which he has in mind. This knowledge can be obtained in two ways. It can be determined from actual experience with similar parts under the same conditions of service (and this is, perhaps, his most reliable method of obtaining his information) or he may use, as indicative of the work which the material will do, results obtained from the various forms of mechanical tests now available.

The investigation of failures which have come to the author's notice, from time to time, has led him to place failures in two distinct categories. In the first one must be placed failures due to the fact that the material did not possess either the mechanical properties or the reliability with which the designer credited it. In the second category (which, by the way, he considers as by far the larger) the material may be shown to possess both the properties and the reliability with which it was credited, but failure has been definitely due to insufficient knowledge on the part of the designer concerning the stresses with which he had to deal. Fatigue failures come, strictly speaking, under either category, but usually under the second.

### THE SELECTED STEELS.

After careful consideration the following steels, selected from the British Engineering Standards Association's specification for wrought automobile steels, were considered to be capable of supplying, with few exceptions, the wants of the automobile and areo constructor, whether he be producing (1) airplanes, etc., (2) touring and racing cars, or (3) slow-moving vehicles. The selected steels may be enumerated as follow:

(1) 40-ton carbon steel.
(2) 0.10 per cent carbon case-hardening steel.
(3) 5 per cent nickel case-hardening steel.
(4) Nickel chromium air-hardening steel.
(5) 3 per cent nickel steel.
(6) 3 per cent nickel chromium steel.

Turning now, however, to the personal point of view, the author would also consider three or four more steels as being of sufficient importance to the industry to merit careful consideration, along with the six mentioned above. These steels are:

(7) Chromium vanadium steel for general purposes.
(8) Spring steels (which will be dealt with under a separate heading).
(9) 12-14 per cent chromium steel.
(10) 0.9 per cent carbon steel.

*40-ton steel*—This steel is preferably an acid Siemens steel containing about 0.45 per cent carbon. The manganese content, which has quite an important influence upon the mechanical properties, should be in the neighborhood of 0.6 to 0.8 per cent. The steel should not be put to work in the forged condition, but should be normalized by heating to a temperature of 850 deg. cent., soaking through at that temperature, and allowing it to cool in air away from draughts.

0.9-1.0 *per cent Carbon Steel*—This steel is included owing to its peculiar adaptability for clutch-plates, keys, etc., and, as has been before stated, is favored in some directions for gudgeon-pins. It may be produced either by the Siemens, electric or the crucible process.

*Case-hardening Steels*—In the author's opinion case-hardening of steels will always have considerable importance in aero and automobile engineering, owing to the fact that in numerous instances local and surface hardness is required, combined with the essential toughness in the part as a whole. These steels are particularly interesting owing to the fact that there is little difficulty, at any rate in the nickel case-hardening steels, in inducing into the part as a whole mechanical properties which are comparable to those of the high-tensile steels.

The 0.10 per cent carbon case-hardening steel, and the 5 per cent nickel case-hardening steel have been selected, to the exclusion of others, since it is felt that if there is any need to improve on the mechanical strength obtained in the case of the 0.10 per cent carbon case-hardening steel, the best thing to do is to proceed immediately to the 5 per cent nickel steel.

Commenting upon the comparative properties of the carbon case-hardening steel as against the 5 per cent nickel steel, the essential difference is that the mechanical strength of the core of the nickel steel is very much greater than that of the carbon steel, although the actual hardness of the hard surface produced on the carbon case-hardening steel is a little greater than the hardness of the hard surface produced by carburizing on the 5 per cent nickel steel. This difference in hardness is, however, of a small order, and except in very special instances, is of little importance compared with the great increase in mechanical strength induced by the presence of the nickel.

*Air-hardening Nickel Chromium Steel*—This steel is introduced largely for gears, although it is considered that the mechanical properties of the material are such that time and a more complete understanding of the steel will lead to its more extended adoption for many other parts. Essentially the steel consists of a 0.30 per cent carbon steel, to which has been added just over 4 per cent of nickel, and about 1½ per cent of chromium. The final treatment consists of heating uniformly to a temperature of 810 to 820 deg. cent., followed by cooling in air away from draughts. Unless the

*Abstracts by the *Auto-Motor Journal* of a paper read before the Institution of Automobile Engineers, on April 14th, 1920.

heating is perfectly uniform, and the cooling is conducted in such a way that the part cools fairly equally, distortion is liable to result. The practical experience of many people has, however, resulted in a gradually increased use of this material. After the air-hardening operation, it is advantageous to re-heat to temperatures of 200 to 250 deg. cent., which treatment has the advantage of eliminating any stresses left in by the air-hardening treatment.

*3 per cent Nickel Steel.*—This steel requires little comment. The author would, however, observe that it should be hardened and tempered if the best mechanical properties are to be obtained. If hardened and tempered the result is a high-tensile steel with maximum ductility. This steel is a safe steel to use, and is less liable to suffer materially in mechanical properties, through inaccurate treatment, than some of the other alloy steels.

*3 per cent Nickel Chromium Steel*—This steel is in effect the 3 per cent nickel steel to which has been added 0.5-1.0 per cent of chromium. The addition of this chromium produces a steel which hardens more effectively, and this, of course, means that parts of thicker section are most usefully made in it, since hardness through the mass is more easily obtained than in the absence of chromium.

*Chromium Vanadium Steel*—There has been much discussion on the merits of chromium vanadium steels, but the author is quite satisfied that the chromium vanadium steel and some of the chromium steels are well worthy of careful attention from the industry. For rear axles, propeller-shafts, transmission shafting, etc., chromium vanadium steels have given extremely satisfactory service, and for that reason it would be unwise not to give them sufficient prominence in this work. It is believed to be a fact that these chromium vanadium steels have earned their present reputation chiefly through the almost entire absence of failures in parts produced from this material.

*12 to 14 per cent Chromium Steel*—The "stainless" and non-rusting properties of this steel, coupled with its high mechanical properties, lead the author to suppose that its use in the aero and automobile industries will be limited only by economic considerations. There are undoubtedly many parts for which it is admirably suited. The essential thing to remember is that the steel must be hardened and tempered if its available properties are to be obtained.

## VALVES

The valve problem is the one which, perhaps, gives the greatest scope to the metallurgist. The steel employed must have good mechanical properties, but, further, must sufficiently maintain its strength at high temperatures. Exhaust valves have to withstand temperatures from 200 deg. cent., up to well above the critical point, while inlet valves have also to stand considerable temperatures, in some cases high enough seriously to weaken many steels. The steels which best resist a diminution of strength with increase in temperature are high tungsten steels and high chromium steels.

The 12 to 14 per cent chromium steel is recommended for high-temperature work. A considerable amount of experience has indicated that this material is adequate for this work, and it has the further advantage of being less expensive than the tungsten steel. Where temperatures are not so high, then the 3 per cent nickel steel, and in some cases low carbon steels, may be, and are, satisfactorily employed.

## SPRINGS

In discussing springs, we have two essential types to consider: (1) valve springs; (2) bearing springs. The author has a considerable amount of experience in the particular field, and has no hesitation in recommending chromium vanadium steel for valve springs. Actual stringent service conditions have shown that this material, in a suitably hardened and tempered condition, gives excellent service.

For bearing springs there are two steels which adequately meet the case, namely, chromium vanadium steel and silico-manganese steel. What is wanted in a spring is a very high elastic range, accompanied by a freedom from intrinsic brittleness.

## STEEL CASTINGS

Early in the war, Mr. Pomeroy read an extremely interesting paper, in which he lamented the fact that the country could not supply its own requirements in small steel castings for automobile work. There are several British firms who are now actively engaged in this field. Small castings can be made of steel of excellent mechanical properties, and the material is an extremely desirable one for such parts as rear-axle castings, fan centers, spring brackets, differential casings, cylinders, gear-boxes, axle-worm cases, road wheels, pistons, axle-jaws, frame-members, etc. The bulk of the steel castings for such purposes run from 0.10 to 0.30 per cent carbon, and should be low in sulphur and phosphorus.

While discussing steel castings, the author would observe that it is unnecessary to confine the composition to that which is largely employed, as steels of various compositions, including the special steels, may be effectively cast, but, of course, require special knowledge and treatment.

## MALLEABLE CAST IRON

Malleable castings are used to a considerable extent in the automobile industry both at home and abroad, particularly abroad. Such material has mechanical properties much superior to cast iron, and for many parts constitutes really an excellent material. Like all other cast parts, however, the main difficulty lies in the fact that the castings are not always free from mechanical defects. In the best-run works these faults may be, and are, entirely overcome. There are two kinds of malleable castings: the Reaumur, or European material, and the American, or "black heart."

## CAST IRON

Cast iron is not used for many parts, its main application being in the cylinder, pistons and piston-rings. Like all the other materials discussed so far, cast iron is worthy of very careful study, and the engineer would be well repaid in controlling the analysis in certain essentials and in having mechanical check-tests—particularly so in view of the fundamental importance of the parts just mentioned. Analysis, dimensions of section and casting temperature are the main factors which determine the ultimate mechanical properties of the material.

As regards the mechanical properties of cast iron, it may be assumed that a good cast iron in automobile castings will have a tensile strength of 14-16 tons per sq. in., accompanied by a yield which synchronizes with the maximum stress with a complete absence of ductility, at any rate, as far as all practical considerations are concerned.

## CONCLUSIONS

Working on the assumption that there is a best condition of some particular steel which will best enable a particular part to fulfill the function for which it is intended, the author has prepared a comprehensive appendix, in which he has made a definite choice of material for each part of (*a*) areo engines, (*b*) racing and touring cars, and (*c*) heavy and low-speed vehicles. This being too long to reproduce fully, we show, against certain of the selected materials, the most important parts relating to the division (*b*):

*Air-hardening Nickel Chromium Steel*—Connecting-rods, transmission gears, steering pinions, steering pivots, steering worms.

*Aluminium Alloy*—Cylinders, pistons, crank-cases, gear-boxes, axle-casings, differential casings.

*Bright Drawn Mild Steel*—All nuts.

*Case-hardening Carbon Steel*—Ball races.

*Cast Iron*—Water-cooled cylinders, cylinder liners, valve-guides, valve-seats, water-jackets, pistons, piston-rings, inlet and exhaust pipes (including manifolds).

*Carbon Steel*—0.9 per cent—Clutch-plates, keys; 40-ton.—Internal and external cone-clutches, dumb-irons, rear-axle housings.

*Chromium Vanadium Steel*—Valve-springs, clutch-springs, chassis springs.

*High Carbon Chromium Steel*—Ball bearings.

*Malleable Cast Iron*—Inlet and exhaust pipes (including manifolds).

*Nickel Steel* (3 *per cent*)—Front wheel stubs, steering arm levers, arms and rods, steering-columns (tubular), steering-swivel forks, chassis frames, front axles, rear axles, torque tubes.

*Nickel Case-hardening* (5 *per cent N*)—Gudgeon-pins, valve-cams, cam-shafts, tappets, timing wheels, differential spiders, gear-box shafts, transmission worms, worm-shafts.

*Nickel Chromium Steel* (3 *per cent*)—Connecting-rods, crank shafts, clutch-shafts.

*Phosphor Bronze*—Worm wheels.

*Silico Manganese*—Chassis springs.

*Stainless Steel*—Valves, rotary pump gears, wire spokes.

*Steel, 40-ton*—Cylinders, brake-drums, brake-shoes, thrust collars and clutch withdrawal collars, differential gear-boxes, front and back wheel stubs, spring shackles.

*Steel Pressing*—Axle-castings, differential-casings.

It will be found that an arbitrary selection of materials has been made, practically within the specifications drawn up by the Steels Committee of the Institution. It must, however, be reiterated, as stated earlier in the paper, that those specifications do not by any means include all the steels which can be used with advantage in automobile engineering. Particularly is it noticeable that the chromium vanadium steels are excluded from the specifications. The author would, therefore, merely instance chromium vanadium steel as indicative of the fact that there are now, and probably in the future will be, still more useful steels which will of necessity compel the designer, if he desires to keep pace with metallurgical development, to take a detailed interest in the metallurgy of the materials of which his parts are constructed.

# Terminal Wastefulness at New York*

## A Study of the Railroad Problem in Its Relation to the Metropolitan District

By Wm. J. Wilgus

I WOULD like to preface my remarks this evening with the statement that of the innumerable problems that press upon us in these crucial times, none should have more earnest thought and more prompt and effective action than the railroad problem. On its wise solution hangs our very means of existence—an uninterrupted supply of the necessaries of life; the continued turning of the wheels of industry, with the fruits of which we purchase our daily needs; an uninterrupted intercourse with our fellow men; and preparedness for defense against the public enemy both within and without our borders.

No matter what our social ills may be, none can be completely cured while there hovers over us the specter of continued strife between the railroad managements and their men, their patrons and the general public, with resultant inefficiency, complete or partial paralysis of service, and the stoppage of the flow of capital into railroad expansion and improvement.

Until the railroad problem of the Nation as a whole is rightly solved, I do not see how our local problems can be settled, for, apart from the other features, without new capital we are helpless to remedy our local ills.

I am among those who believe that the railroad legislation under which we are now acting does not go to the root of the disease; and that reasonable harmony will not ensue and capital will not be induced to return to the railroad field while we have such an illogical situation as the private ownership of uncoördinated quasi-public property, regulated and controlled by governmental agencies which in large degree are not responsible for the financial outcome of their acts.

However, we must assume that in some manner yet to be worked out, as was for instance suggested in my remarks before the Society on November 19th last, a cure for the existing evils will be found; and through governmental or private channels money will be forthcoming for railroad purposes.

Metropolitan New York, then, should be ready with well thought out plans of its needs, not only from its more selfish standpoint as a community of some seven million souls, but in a wider sense as the world's principal gateway to a nation of one hundred million people. The problem here is not merely a local one, but is national in its bearing; and therefore the widest vision and the best brains and experience of the country, if not of the world, should be devoted to its consideration. This much is due to the localities affected, and to the Government at Washington to which the people of the country look for the expenditure of public funds at the port of New York in such manner as to increase its usefulness as a national gateway in times of both peace and war.

It should be realized that the port of New York is the meeting place of water and land carriers, and that there, in the interest of economy and speed, everything possible should be done to eliminate obstacles to their closeness of contact. Trans-atlantic and coastwise steamers, and canal barges and harbor craft, there exchange traffic with each other and with motor trucks for local distribution, and with the railroads which connect the port with the hinterland.

That everything possible has *not* been done to bring these agencies of transportation in proper contact is proven by the chorus of complaints from all directions that terminal costs and delays at this port are excessive and well nigh unendurable.

One member of the Interstate Commerce Commission, in designating New York the "terminal sore spot of the Nation," contrasts its average terminal cost of $35 per car with $2.50 for like service at San Francisco, with a similarly low charge at New Orleans, and with still lower costs at other points.

Civic and commercial organizations at New York are practically unanimous in their condemnation of terminal wastefulness at this port, which, they say, if unchecked, will bring ruin to its supremacy.

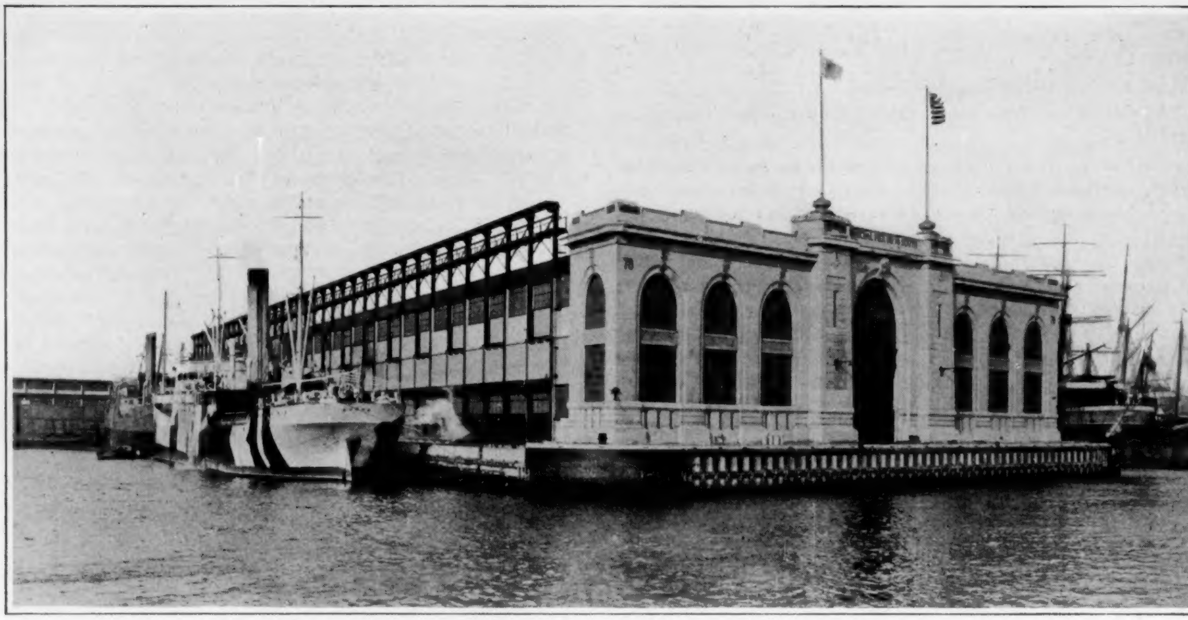
We are all aware of the congestion here during the war which endangered the success of our armies abroad, and we all know of the ever present delays and expense of distributing food, coal, building materials and other necessaries to our local population.

The question naturally arises—what are the conditions which have brought about this intolerable situation?

First, there is the deep channel of the Hudson River, originally the cause of the city's greatness in the heyday of inland water transportation, but now a natural barrier between the terminal of the eight trunk lines on its western shore and the centers of population and shipping on Manhattan and Long Island.

A car from the West cannot be taken direct to shipside or consumer at points east of the Hudson, but on reaching the terminus of its roadhaul from the interior is switched to congested yards on the New Jersey or Staten Island waterfront. There the car is either placed on a float and taken across the river or harbor to local freight terminals on the waterfront, at which high rentals and congested surroundings cause

*Read at the meeting of the New York Section of the American Society of Civil Engineers May 12, 1920.



OUTSHORE END OF MUNICIPAL PIER NO. 78 SOUTH, PHILADELPHIA

excessive costs and delays in the transfer of the contents to trucks for surface distribution on crowded streets; or its contents are transferred to lighters and floated to shipside, wharf or pier, where the freight is again handled one or more times before final delivery to truck or ship.

All of these operations are not only costly in labor and productive of delays to freight, but they involve the use of waterfront on both shores, badly needed for legitimate waterborne commerce; they involve the employment of a vast uncoördinated fleet of tugs, car floats and lighters in a harbor that is often fog and storm bound, and under circumstances that cause duplications of effort; and they involve prolonged idleness of railroad equipment at times when the country is suffering acutely from car shortage.

The second condition that contributes to excessive costs and delays in this port is that of narrow, craneless steamship piers on which there is insufficient space for the sorting and temporary storage of cargo, for motor truck driveways and for suitably arranged railroad tracks.

This highly undesirable condition is the result of the Topsy-like growth of the port from the time when railroads and motor trucks were unknown, and short narrow piers, usually constructed on the prolongation of the abutting streets, were sufficiently spacious for the sailing vessel and small steamer of the day. When the railroads came along the practice of narrow piers was therefore already established, and circumstances have conspired to prevent a change, despite the remarkable growth in the length and capacity of ships and the increasing burden of harbor lighterage.

One of these circumstances is the requirement in the rate from the interior that the rail carrier shall deliver freight at ship-side, in consequence of which the water carrier, who usually controls the pier, naturally has no incentive to abandon the "off-side" delivery of railroad freight by water in exchange for direct rail delivery over a pier that is too narrow for that purpose. To accept this exchange the water carrier would suffer inconvenience and expense in order that the rail carrier might profit.

Another of these circumstances is the practice of placing the pier under the whole jurisdiction of the water carrier instead of treating it as a joint facility for all carriers, both land and water. For the water carrier to consent to piers of sufficient width to accommodate a proper arrangement of railroad tracks would, under the policy in vogue in Manhattan, mean higher rentals at his sole expense, from which he would reap incommensurate benefits. Then too the presence of but one trunk line on Manhattan has served to discourage the laying of pier tracks which are inaccessible to the other rail carriers.

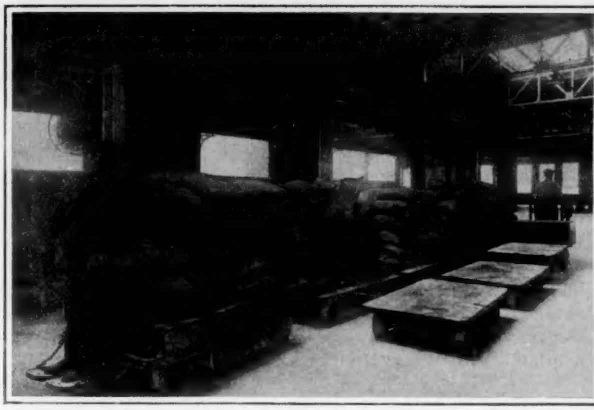
It is therefore easy to realize why the narrow trackless pier has held its own in New York despite its obvious great disadvantages from the broader viewpoint of the general good.

Thus it will be seen that the primary causes for excessive terminal costs and delays in this port are: First, a lack of coördination between the carriers; second, the interposition of a water barrier between the main land and the leading centers of the port, which imposes on the rail carrier the burden of effecting its collections and deliveries by means of waterfront operations on both shores plus lighterage; and, third, the requirement in the seaboard rate that the land carrier shall deliver and receive freight at ship-side, thereby removing the incentive to the owner or lessee of the pier, the water carrier, to advocate more efficient interchange facilities from which the major benefits would go to those who would not share in the cost of providing them.

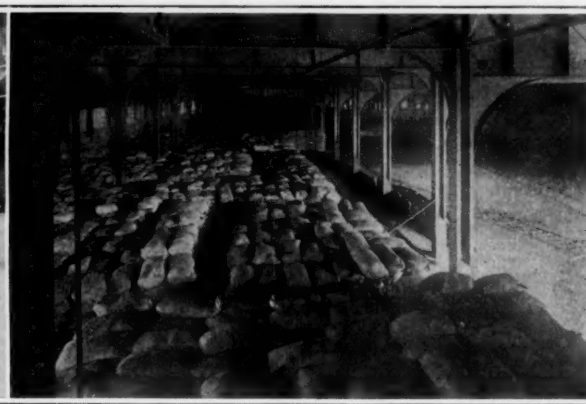
How then in the public interest may these obstacles to progress be overcome? I venture to offer my suggestions on that score as follows:

All of the rail carriers of the port should be linked with each other and with the waterfront by means of an outer belt line sufficiently removed from the center of the community to offer plenty of elbow-room for future growth and for industrial development.

Such a location might extend from the New York Central in the vicinity of Yonkers, westerly to the West Shore R. R. near Dumont; thence continuing west to the rear of Paterson, intersecting the various lines of the Erie and Delaware, Lackawanna & Western railroads; thence southerly along the Passaic River to a crossing of the divide near the Delaware, Lackawanna & Western R. R. at Summit; thence southerly and easterly via So. Plainfield to Perth Amboy, intersecting the Central Railroad of New Jersey, Lehigh Valley R. R., Philadelphia & Reading R. R., and Pennsylvania Railroad; thence northeasterly across Staten Island to Stapleton, where connection would be made with the Baltimore & Ohio R. R.; and thence under the Upper Bay to Bay Ridge on Long Island, from which connections would radiate to the Brooklyn waterfront to Jamaica Bay, and via the Long Island and New



ELECTRIC TRUCKS IN SERVICE ON PIERS 38 AND 40 SOUTH, PHILADELPHIA. MAXIMUM HAULING CAPACITY 11,000 LBS.



NORTH SIDE OF MAIN DECK, PIER NO. 78 SOUTH, LOADED WITH 8,346 TONS OF FLOUR. NOTE CAR TRACKS AT CENTER

York Connecting railroads to points in Long Island and the Bronx.

This route or some modification of it would enable the railroads to interchange freight and passengers, as well as troops and supplies in times of war or insurrection, at points remote from the congested regions of the port; and to deliver them, without the expensive and uncertain intermediary of harbor floatage, direct to bottoms along the waterfront of all sections of the port except Manhattan. From a transportation standpoint this would transform the sections of the port that are now marooned on Long Island and Staten Island into integral parts of the mainland.

The experience of practically every other great city has demonstrated the inestimable value of a coördinating agency of this kind in promoting economy, speed and safety. The latter advantage was strikingly proven at Paris during the World War, where the outer belt line, as a means of quick movement of troops and war supplies around the city, in several instances saved the day. Why should we not have this protection in the interest of the Nation itself and of this great community?

With the creation of the outer belt line, at which in time large yards would be built for the termination of the trunk line road haul, there should be a unification of the management of all transportation facilities within its circumference, including the inner belt lines, waterfront developments of a public nature, and the portion of the lighterage fleet which would be retained for the character of terminal service that must continue to be handled by water.

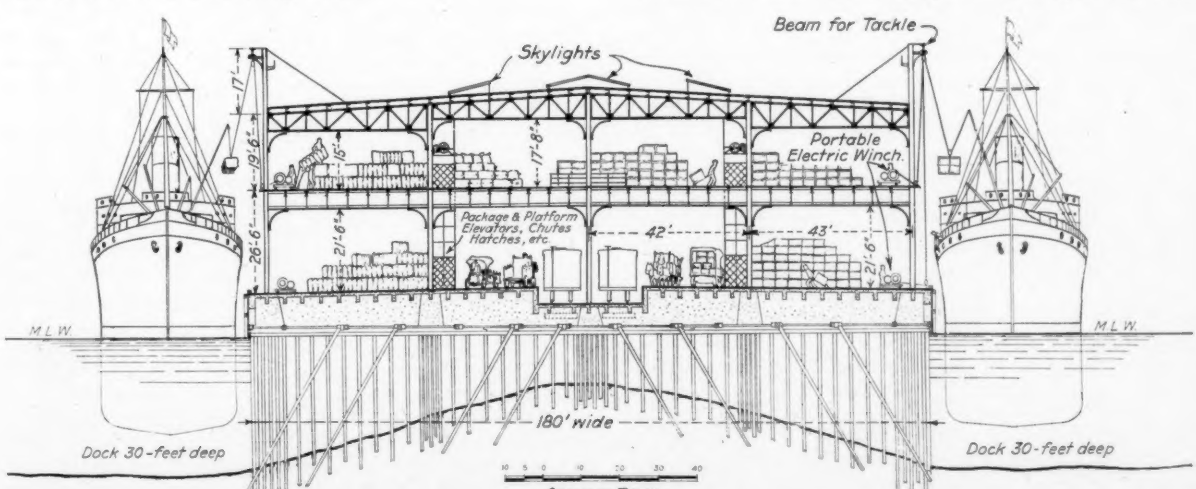
Within this consolidated terminal zone it is natural to expect that in time all railroads would be electrically operated, thereby extending to the Staten Island and New Jersey sections the well known benefits of electrification now enjoyed on Long Island and Manhattan.

The adoption of this general plan, with its manifest commecial and military advantages, would carry with it the gradual abandonment in New Jersey, Staten Island and Long Island of the narrow type of pier, now alone persisted in by New York among the great ports of the world, and the substitution of piers of ample width and length for the accommodation of the largest ships, and equipped with commodious motor truck driveways, track layouts suitable for continuous cargo handling, spacious areas for sorting and temporarily storing cargo, and labor and time saving mechanical devices.

The economy that would flow from the adoption of modern piers is easily provable, and their increased cost would be a comparatively small percentage of the combined investment in those features whose effectiveness would be enormously benefited thereby, namely, ships, cars, harbor equipment and waterfront.

Again reverting to the experiences of the World War, it was found that the chance of our military success was greatly multiplied through the use at the French ports assigned to our army, of mechanical appliances in conjunction with adjacent tracks for the quick release of vessels freighted with mixed cargoes ranging from small boxes to bulky railroad materials, machinery, guns, camions and fighting tanks.

Of course it would not be proper to load upon the water




SOUTHWARK PIERS NO. 38 AND 40 S. W., PHILADELPHIA—A TYPICAL CROSS-SECTION

carrier the entire burden of the increased cost of such modern facilities, from which other interests would reap an important share of the reward. This is a question that should be disposed of through negotiation. The main thing is to bring about the adoption of plans that will be most helpful to the port as a whole.

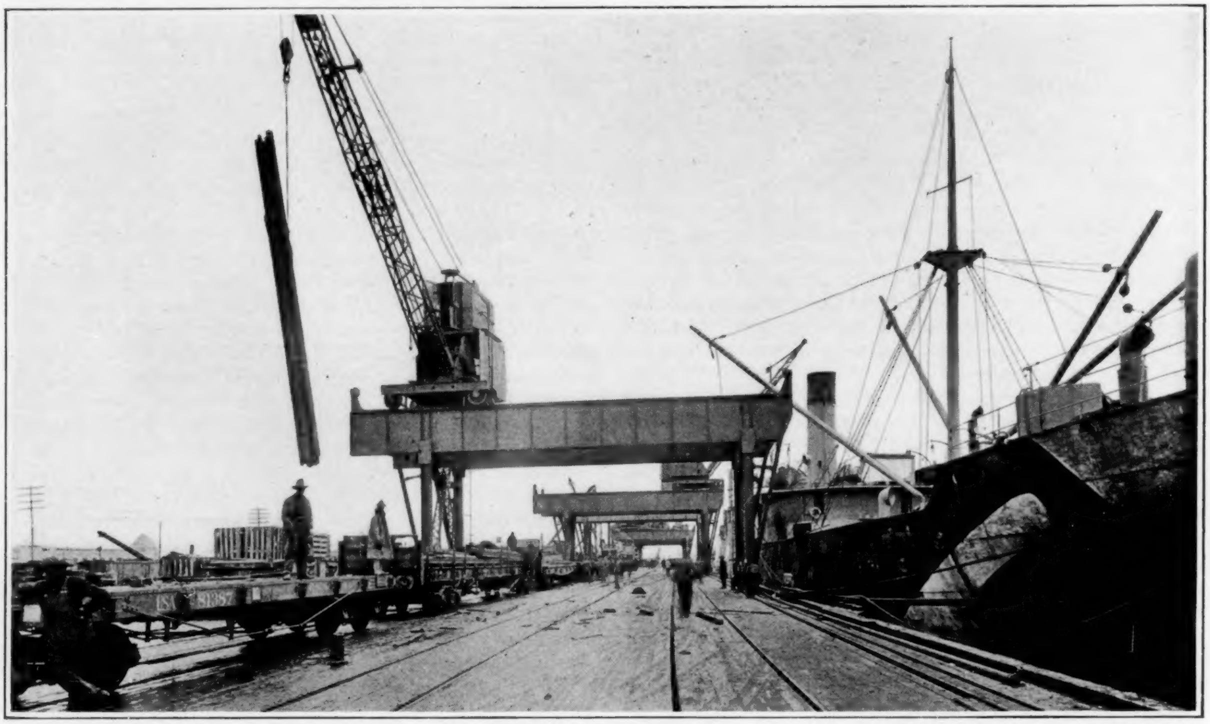
As to Manhattan, I hope that I am not alone in the belief that its cramped quarters forbid that it should be served in the future with a New Jersey joint freight connection that would permit all the trunk lines to place their large cars on the island. There is insufficient space for sorting and storage yards at the proposed termini on the island, the existing pier widths are too narrow for direct rail access thereto, the added concentration of traffic on city streets would promote further congestion, and the public indirectly would be burdened not only with increased interest charges but also with increased cost of operation, instead of the decrease which they have a right to expect.

I have long held, inasmuch as somewhere there must be the transhipment of Manhattan freight from the standard railroad car to a distributing vehicle, that rather than do this on costly property, among congested surroundings at concentrated localities as near as possible to Broadway, it would be far more economical, convenient and speedy to perform this act at trunk line termini on the New Jersey meadows, in conjunction with which the freight would be carried in trains of electrically operated multiple unit vehicles beneath the river, and through small subways near the surface, to and from many points in the city where there would be direct contact with the large shippers, or where mechanical devices would transfer the removable containers from the subway vehicles to motor truck chassis for short radius "stoor-door" delivery. This idea has for its mainspring a policy of diffusion rather than concentration of market products, fuel and other freight, combined with the release of a large part of the valuable waterfront for legitimate waterborne commerce, the relief of street congestion, and a unified control of the borough's system of distribution.

The two States are now proposing the construction of a vehicular tunnel between Canal Street, Manhattan, and Jersey City, but this may be looked upon as a street extension across the river and not as a means of solving Manhattan's freight distribution problem.

A word should be said as to the passenger end of the problem, apart from urban transportation which is a subject by itself.

Plans have been proposed for Hudson River bridge crossings, one in the vicinity of 59th Street and the other at Fort Washington, for the accommodation of pedestrians, motor vehicles and joint trunk line traffic, both passenger and freight. It has seemed to me that either or both of these feats should be accomplished in the comparatively near future, although for the reasons I have expressed I am not optimistic as to their availability for heavy freight service.



AMERICAN BASSENS, FRANCE. DEC. 13, 1918. GANTRY CRANES SPANNING SEVERAL TRACKS. CRANE IN FOREGROUND ENGAGED IN DISCHARGING RAILROAD RAILS

In light of these suggestions for an outer belt line, coupled with direct rail connections to piers in New Jersey and on Staten and Long Islands, it may be timely to comment on the waterfront improvement proposed by the City of New York at Stapleton, Staten Island.

At this location, situated as it is in the only borough of the city that lies west of the Hudson River channel and therefore contiguous to the mainland, there is a happy combination of the deepest channel in the port, 40 feet, ample space between the pierhead and bulkhead lines for piers upwards of 1,300 feet in length, existing means of direct rail connection with five of the trunk lines serving the port as well as the promise of future connection with all of them, and a neighboring upland within easy motor truck and rail access well adapted for industrial development as a "free port" or otherwise. Excellent sites for grain elevators, refrigeration plants and warehouses are also in close proximity to ship-side.

It is to be expected that with these outstanding advantages, in many respects unique, the city, guided by wide vision and experience and in consultation with rail, water and commercial interests and with the local and national authorities, would have adopted plans for wide piers equipped with appli-

ances for handling varied cargoes, with adequate track layouts including supporting yards, with motor truck driveways free from grade crossings of tracks, and with transit sheds of ample width for use in connection with the largest type of vessels.

This expectation is heightened by the general knowledge that such provisions have been made at all important ports in the world, as evidenced by pier widths of 300 feet at Philadelphia, 300 to 340 feet at Montreal and Halifax, 400 feet at Boston, 480 feet at Portland, Oregon, 400 feet at London, 550 feet at Hamburg, and still greater widths at other ports.

However, grievous to relate, this obvious course has *not* been followed in the plans as recently published in the S'IENTIFIC AMERICAN.[1]

Of the total of twelve proposed piers of such great length, ten are only 125 to 130 feet wide, and two 209 feet wide. The latter have tracks on the outside only, and the shed width is entirely inadequate for combined sorting and storing cargo, motor truck driveways, and the ultimate provision of interior tracks.

The narrower piers are without cranes. This is a fault that is especially deplorable in view of the future operation of Erie Canal barges which are unequipped with self-handling cargo devices and for which the State elsewhere at barge canal terminals is spending millions for power machinery. Moreover this is to be regretted in view of the surety that in case of war many kinds of cargo must be handled here for which the ordinary ship tackle will be unsuited.

AUTO-TRUCK BEING UNLOADED FROM A SHIP AT BASSENS, FRANCE

Also these narrower piers are without exterior tracks for direct interchange between rail and water carriers, a need sure to arise if the immediate purpose of the improvement should later change under other managements, and sure to arise in case of war stress. Moreover, the width of shed is entirely too narrow for the combined use of cargo sorting and storage and a proper layout of interior tracks for such long piers.

The illustrations of the general layout give no indication of thought as to proper supporting yard layouts and viaduct crossing to neighboring streets and upland.

The answer to the riddle as to why the city, in the face of the crying need for reductions in terminal costs and delays, should fall into these errors, is found in the SCIENTIFIC AMERICAN article which states that the plans were made to suit the wishes of the prospective lessees, the steamship companies, whose policy very naturally is dictated by self-interest rather than the general good.

It is to be hoped that the Federal authorities and enlightened civic sentiment will yet bring about a proper revision of these plans and thus indicate that this port is at last awakened and intends to remove the stigma that it is the "terminal sore spot of the Nation."

Summarizing, it is my opinion that the general railroad problem first must be solved by the Nation in such manner that harmony will reign between the railroad managements and their employees and the public at large, and in such manner that capital will again flow into the expansion and extension of our railroads.

Then, with the needed money in sight, it is my thought that this port should be radically improved by means of the coordination of all terminal facilities in conjunction with an outer belt line over which direct rail access would be had by all of the rail carriers to modern suitably equipped wide piers in New Jersey, Staten Island and Long Island; also by means of bridge crossings of the Hudson for passenger connections between the New Jersey railroads and upper Manhattan, and by a system of underground small car freight distribution on Manhattan.

Pending a comprehensive solution of the problem it is ardently to be hoped that all work done by the local communities, as for instance on Staten Island, will be designed and constructed in harmony with what is manifestly the best for all concerned rather than for a single interest.

If a course like this, or some better one, is not adopted soon, the City of New York will see rival ports prosper at its expense; it will run the serious danger of having the excessive terminal costs of its making transferred, through the change of the rate structure, from the nation at large to its own shoulders; it will furnish ammunition to its opponents who are striving to bring about the by-passing of this port in favor of the proposed St. Lawrence deep route to the Great Lakes; and it will attract less and less coöperation from the Federal Government which cannot fail increasingly to appreciate the injury to the newly established American merchant marine and to the Nation's preparedness in case of war, if this imperial city does nothing to cure its ills.

As engineers have we a higher purpose than to awaken our fellow citizens to an appreciation of the gravity of the problem, and to point a way to its solution?

I fully realize that the ideas that I have expressed are open to great improvement or to radical change. It may be, however, that they will serve a purpose by calling forth constructive criticisms and suggestions that will prove of real value to the public.

[1]*Scientific American*, May 1, 1920, p. 492.

## WHITE COAL AVAILABLE IN CANADA.

THE Committee on Water Power of the Commission of Conservation of Canada, following a survey of the total available water power of that country, reports that Quebec has 6,000,000 available horse-power; Ontario, 5,800,000; British Columbia, 3,000,000; Manitoba, 2,797,000; and a considerable amount of power in other parts of the Dominion, totaling in all, 18,832,000 horse-power.

It is estimated that more than 85 per cent of the total electric-generating-station capacity in Canada is derived from water power, the remainder being nearly all steam power. Efforts toward more complete utilization of this power are under way. Last year there was completed throughout the Dominion installation of plants aggregating 64,000 hp., and plants at present under construction total over 370,000 hp., while other developments planned for the future will increase this by about 750,000 horse-power.

Two methods, entirely different, have been developed for dealing with water-power problems in Ontario and Quebec. Each seems to be successful in its own area. The Hydro-Electric Power Commission of Ontario has jurisdiction over all water powers in that province. The commission is carrying out its own developments and operating its projects. In Quebec the Quebec Stream Commission is taking all necessary steps to make water power available by private companies. —From *Power*, May 18, p. 796.

# Increasing the Utility of the Tractor

## Necessity of Adapting the Tractor to the Farmer and the Farmer to the Tractor

### By Arnold P. Yerkes

IT is now more than fifteen years since the gasoline tractor was first used in quantity for farm work. The tractor is, therefore, almost as old as the automobile and is really older than the motor truck. But in spite of the fact that several million automobiles are in use and a million or more motor trucks, the number of farm tractors in use at the end of 1919 will probably be 100,000 short of the half-million mark.

This comparatively slow introduction of mechanical power for farm operations has been a surprise and a disappointment to many people. Numerous companies have been organized to manufacture tractors under the belief that the business was sure to grow at a tremendous rate, and that there would be room for many companies to manufacture the tractors they had been told that farmers were waiting to buy, and which they must have at once to replace the expensive horse. Company after company has become involved in financial difficulties because the farmers did not take advantage of their opportunity to relieve themselves of this burden. A great many of these early mechanical horses were rather freakish and incapable of meeting the requirements of the farmer; but in addition to the rather long list of machines of poor design and construction, a few, even among the early makes, were sold in large numbers and proved a profitable investment for the farmers.

It is easy to understand why the machines which were deficient failed to sell. It is not quite so clear why the really efficient outfits failed to make greater headway. Some have blamed the poor tractors and their effect upon the farmers for the slow progress made in introducing those of more satisfactory design and quality. Others have thought that no really efficient tractor of just the right size and possessing sufficient all-around usefulness had been produced. They have professed to see a wonderful and immediate market for the tractor that would fully meet the farmers' requirements. Others still believe, or profess to believe, that past and present tractors have been lacking in quality of material and workmanship to such an extent that they failed to meet the farmers' requirements for durability, and that what is needed to give the business proper acceleration and increase sales is the attainment of the highest possible quality, so that the tractors will be capable of working steadily for several seasons on farms, without danger of delays and expense due to breakdowns and repairs.

No doubt the failures of tractors to succeed on some farms has had the effect of making neighboring formers rather slow to try one, but certainly this cause alone has not been either wholly or in large part responsible for the slow adoption of tractors during the past several years. It may be true also that some farmers are waiting for a tractor capable of a wider variety of work than those now available, although it is difficult to conceive of a wider range of usefulness than is claimed for some machines now on the market, but which do not seem to enjoy any greater rapidity of distribution than other machines of more conservative design and with a shorter list of claimed accomplishments.

As to the need of better quality to increase sales, the tractor would be in a class by itself if highest possible quality were essential to secure its general or extensive adoption. In almost every line of manufactured goods there is a wide range of quality, and this variety exists because the trade demands it. No matter what the article, there is usually a choice of quality ranging from the poorest to the best for which any demand exists. For a few dollars a watch can be purchased which will keep time fairly well and answer all practical purposes. For several hundred dollars one can buy a Swiss hand-made watch which will not vary more than a fraction of a second per month. There is a demand for each kind, but the lower-priced ones sell in the greatest numbers. This should not be overlooked, for it holds true of many other things besides watches, not excepting tractors. Many men who buy watches with high-priced works, and add still further to the cost by getting a handsome case, will, when buying a pocketknife, get a comparatively cheap one, perhaps paying more attention to appearance than to real quality, because they have little use for a knife. But others will spend a greater amount for one having blades of higher-quality steel, because they feel that it pays them to get a knife of good quality. The quality depends, to a large extent, upon the amount one is willing to pay. The tractor is no exception. There is some demand for a tractor of highest possible quality, but there is no more reason for having all tractors of this superlative quality than for having all watches Swiss hand-made, or all jackknives hand-forged from crucible steel.

#### FARM-TRACTOR ADOPTION DATA.

No one can make a thorough study of the existing situation and conclude that any or all of the reasons mentioned are even in a large part responsible for the slowness in adopting the tractor more generally on the farms. It is obvious that there are other strong influences. Most of these are connected with the farm business itself, and by considering the matter in the light of the individual farmer rather than of farmers as a class, these influences become more clear. Considering the subject in its broader aspect and using available statistics, one of the strongest reasons becomes quite obvious. There are on farms in the United States between 300,000,000 and 350,000,000 acres tilled each year. This acreage varies according to market conditions and also according to weather conditions during working seasons. There are about 25,000,000 work horses and mules on farms in this country, or at least one work animal for every 14 acres of tilled land. On a great many general farms where horses are the sole source of power for field work, only one animal is kept for every 30 acres of tilled land and the work is carried on in a very satisfactory manner. It would thus appear that there is at present an abundance of animal power available for farm operations. In spite of the enomous increase in the number of automobiles, motor trucks and tractors, the total number of horses has shown no great decrease, although the latest Government figures show for the first time in several years a decrease in the number of work animals. But the point is that these animals are in the country and, since the average life of a work horse is about twelve years, at least half can be expected to be still available five or six years hence, and their colts will continue to be raised in large numbers, although in smaller numbers than previously.

The price of work horses has decreased gradually for several years, owing to the high cost of feed and the falling off in the city demand for horses because of the increased use of motor trucks for city hauling. Farmers will not kill off their horses simply to buy tractors; neither will the individual farmer sacrifice his work stock to buy a mechanical power-plant, although he may believe it might prove more efficient and satisfactory than horses. In addition to the very important fact that we have such a plentiful supply of work animals that universal adoption of mechanical power must await their passing, there are three other influential factors necessary to bring about the more general utilization of the tractor.

*Reprinted from the *Jour. Soc. Automotive Eng.* April, 1920, pp. 226-230.

(1) A lower first cost, or greater financial return for farmers, or both.

(2) Perfection of machines and attachments for the tractor and motor truck which will permit their use to better advantage for some of the work for which horses are still used, and also reduce the human labor required.

(3) Informing farmers how to reorganize and enlarge their farm business by crop rotation, etc., to utilize the tractor to advantage and also maintain soil fertility.

Any suggestion of lower prices for tractors under present conditions seems unreasonable, but either these must come before tractors will be used in really great numbers or farmers as a class must receive greater returns, to make more of them financially able to purchase tractors at present prices. The latter alternative may not appear logical to those who believe farmers as a class are able to buy almost anything. Such a belief is, however, far from being in accord with actual facts. Many people make the mistake of judging farmers as a class. They may have an intimate knowledge of a few individual farmers, their financial circumstances and general surroundings. If they visit friends or relatives on a farm, they are apt to visit those who are more prosperous than the average and who have a home and general surroundings conducive to such visits. All farms are not of this nature. A large percentage of American farmers are tenants. Among these tenants many have been hired men or farm boys, who have had little money to begin farming and were gradually working their way up. If they have lived in a community a few years and shown themselves honest and industrious, they can often obtain a farm either on shares or for a small cash rental, even though they have very little stock or equipment. Many retired farmers are willing to advance money. They are accustomed to increasing their powerplants by raising colts, or by purchasing young colts, perhaps working in part payment for them and raising them as cheaply as possible on pasture and roughage otherwise of little value. Many of these tenant farmers are in no financial position to buy tractors even if desirous of so doing. It is true that many of them have sufficient credit to buy a tractor, and the same holds true of many who have passed through the tenant stage and acquired title to a farm, although under a heavy mortgage. A loan to an honest and industrious man with a family is always reasonably safe, and country bankers know this. However, many of these men and their wives hesitate to incur more indebtedness until they have paid off some of the mortgage and perhaps obtained necessities and luxuries which they feel they would rather have than a tractor. In some States nearly half the farmers are renters. A large percentage have comparatively little capital and are making, as a rule, a very small net income. Their available surplus can always be used for buying numerous articles for the comfort and enjoyment of their families, and it is small wonder that so few of them purchase tractors.

In spite of all reports about profiteering on the part of the farmer, the returns on his invested capital and for the amount of work he puts into crop and stock production have been, as a rule, pitifully small. Most farmers today have begun with little or nothing and have gradually acquired land, work stock and other livestock. It is an exception if they have any great sum of money to invest at any time; and, when they do have money to spend, there are many ways in which to spend it. While farmers as a class are getting greater returns than was formerly the case, they must also pay much more for almost everything they need. They are also living on a somewhat higher plane, and naturally do not propose to return to former conditions simply to have money to invest in some particular machine. It is no longer considered wise to keep children out of school following the sixth or seventh grade to help with farm work, but it is more and more common for children to go through high school or college, and this is expensive. The farm lighting plant, a water system for the farmhouse and numerous other improvements practically in the same class with the automobile, must be considered, so far as having the support of the entire family is concerned.

THE FARMER'S INCOME.

What must the individual farmer spend for all his numerour purchases? Frequently, figures are printed which have been compiled as to the amount of money represented by the total crops produced, and which farmers will have to spend. Most farmers, however, who read such figures must wonder where their share of this sum is. How much money will a farmer be likely to receive from a corn-belt farm of 200 acres, representing a return much above that of the average farm? Corn is the principal cash crop in the corn-belt and the one returning the most profit. Assume that of the 200 acres, 100 acres are in corn. The average yield per acre does not quite reach 40 bushels even in the corn belt, but assuming 40 bushels per acre, the farmer would harvest 4,000 bushels. Until the war, corn has usually been about 70 cents per bushel, but even during the last several years $1.50 per bushel at the farm is a very high estimate. This gives a gross return of $6,000. Suppose the other 100 acres is divided between oats and alfalfa. A fair average for the corn belt is 50 bushels of oats, and 50 acres at this rate would give 2,500 bushels. At 70 cents per bushel, a liberal price, this would be $1,750. Fifty acres of alfalfa with a yield of 3 tons per acre would mean 150 tons, and at $10 per ton at the farm would give a gross return of $1,500. Figuring thus liberally, a 200-acre corn-belt farm could not be expected to produce more than a gross return of $9,250. If this were only a net amount there would be a stronger demand for tractors, even at high prices. Unfortunately, heavy costs such as labor, interest or rent, taxes, seed, overhead charges, etc., must be deducted. A low price for much of the present corn-belt land would be $200 per acre. At 7 per cent the interest on the land investment of a 200-acre farm would be $2,800. Of course, part of this interest would probably be available to the farmer, but a large percentage of farms have heavy mortgages. It would therefore be not at all too much to deduct $2,000 interest charge from the gross total. The work stock, according to the common estimate, would require 5 acres for each head. At least eight and perhaps ten work horses would be kept on a 200-acre farm today, but the former number, at $125 a year, would cost $1,000. Including board and other expenses another $1,000 will not cover the cost of hired labor. Overhead costs on buildings, fences, machinery, marketing and numerous other items of actually necessary operating expense will in almost every case reduce the net income to considerably below $2,000. This must provide part of the family's living expense, supply them with clothes, furnish the house and provide whatever recreation and luxuries they are to enjoy.

If an absolutely fair calculation is made, it is evident that a farm as large as 200 acres is not apt to return a sufficient profit to allow a farmer any great amount of money to invest in new machinery. The income from farms is, as a general rule, in direct proportion to their size for any given type. On corn-belt farms of 80 to 160 acres, the net returns are very low compared with those from most other kinds of business having anything like an equal investment of capital. Numerous investigations have shown without exception that the net income from farming is very small. In spite of all that may be said and believed regarding their enormous profits, farmers appear to be anything but satisfied with conditions as they have existed in the past and are found at present. Farmers show almost as much unrest and dissatisfaction today as labor unions show. On every hand they are endeavoring with more or less success to better their conditions and obtain a more adequate return for their labor. The Non-Partisan League movement in the Northwest is one evidence of this. The forming of numerous coöperative associations is further evidence, and to show the frame of mind of

many farmers, attention may be called to the resolution recently passed by the Indiana Division of the Farmers' Educational and Coöperative Union, which called for a reduction of 25 per cent in the acreage planted to crops in 1920. The effect of carrying out such a resolution would be far-reaching, as is obvious. Nevertheless, it is quite likely that it will be carried out to a great extent. At any rate, reports already received as to the acreage of fall-sown grains in Illinois show a very heavy decrease, amounting to 50 per cent in some counties.

These conditions might at first glance seem to have little relation to the sale of tractors, but they do have a very strong influence. The farmer is in a peculiar position. He can always procure a fairly good living from his farm. If he and his family are willing to stint themselves somewhat in regard to articles which must be purchased, they can continue to exist even though the money returns from crops are extremely low. This fact has been largely responsible for so many farmers remaining in the business when they were not receiving an adequate return for their labor and invested capital. It enables them to reduce their tilled acreage and so cut down their expense for hired labor and operating cost, resulting in a public shortage of food supplies, which may still return them fully as much as a larger crop at lower prices. While thousands of farmers are in this frame of mind, it is useless to expect them to buy tractors. The real solution of their problem undoubtedly lies in increasing rather than decreasing their acreage, and in bringing about greater returns for their labor through the more efficient utilization of their labor by large labor-saving machines. Unfortunately, this is not being pointed out to them to any great extent.

It is impossible to calculate with any degree of accuracy the probable market for tractors today, without taking into consideration the economic problems with which farmers are confronted. The changed conditions brought about by the war have affected the farmer almost as much as the business man. The labor situation is perhaps even worse from the farmer's standpoint than from that of the industrial employer.

### HUMAN VS. MECHANICAL LABOR.

In two principal ways, farmers attempt to free themselves from the hired-help problem. One is to cut down the acreage being farmed and either engage in dairying to some extent or undertake the growing of crops which will provide employment for a large number of days each year, can be handled with little or no extra help and, because of the large amount of labor involved, return a greater amount of money per acre than crops usually grown by machinery. The other solution is to increase the size of the farm to permit utilization of the largest and most efficient labor-saving machinery, to operate on a sufficient scale to permit paying wages on a competitive basis with city industries and to provide enough work for both men and equipment to justify the necessary investment and overhead charges.

A number of companies and corporations have been formed within the past few years to carry on farming on a large and efficient scale, and this movement has doubtless just begun. Most of those engineered by experienced farmers seem to have proved profitable. Some have involved the growing of perishable truck crops and small fruits; others, general farming only. One of the largest and most recently formed is reported to be a $20,000,000 corporation to handle fruits only. This organization, like most of the others, expects to reduce the overhead charges through buying supplies and equipment in large lots, proper advertising of the product, ability to handle the entire marketing problem in a much better manner, using tractors and other large machines in all field work. Their financial resources will permit them to buy an adequate supply of the most modern machinery, and their large acreages will fully justify it. Great benefits have been predicted from these large farming schemes, and there are certainly enough possibilities in them to cause many more to be undertaken. One of them is of more than usual interest, because it was backed largely by representative capitalists and inaugurated as a war measure. It was planned on a magnificent scale, and was located on several thousand acres of Indian land. This section was recently stricken by a drought, and the wheat crop was a total failure. This experience should give business men a better conception of the risks involved in farming. It also shows that even though a farmer may make money some years, such profits must make up for the bad seasons which occur too frequently, even in desirable farming regions. It has often been stated that there is no such thing as an average farm and it is just as true that there is no such thing as an average farmer. There are always great variations in the problems presented by any two farms. To classify them, the best that can be done is to place in a group those that are least dissimilar. In this great dissimilarity of farms and farmers lies another reason for the slow rate at which tractors have been bought. It does not follow that because one man on a 240-acre farm in the corn belt finds a tractor profitable, his neighbor with the same sized farm will find a tractor equally profitable. The crop rotations on the two farms may be quite different. One farmer may like horses and raise colts for sale, while the other does not; one may be a good hand with machinery or may have a son or hired man who can operate a tractor satisfactorily, while the other may not; one may depend upon hired help, while the other may have boys of his own to assist him; one may have passed middle age and, like most elderly people, be rather averse to making any radical changes in his methods or equipment, while the other may be young, energetic and perfectly willing to try something new; one may have money laid aside either as the fruit of his own labor or through inheritance, while the other may be financially handicapped; and one may have excellent credit with his bankers and local business men, while the credit of the other may be poor. Thousands of other variations could be listed, each one of which actually exists in some instance. The size and type of farm are far from being the only factors which determine whether a tractor will be practical and whether it is likely to be used.

### EQUIPMENT AND METHOD CHANGES.

Attempting to put a tractor on every farm above a certain acreage would be like trying to sell a motor truck or delivery car to every corner grocer in our cities. In Chicago, there are hundreds of small grocers who each maintain a horse and wagon for hauling goods from the wholesale house and delivering to customers. This does not mean that automobile delivery is not quicker, cheaper and more desirable in almost every way, but that the horse and wagon have in many cases been owned for a number of years, are still serviceable and meeting the requirements. Even if the storekeeper desired to sell his present outfit and purchase an automobile, he would find a very poor market for either the horse or wagon; hence, the new equipment would mean a considerable investment increase and an actual loss through the sacrificing of serviceable equipment. So long as he sees no probability of an increase in his business that the horse and wagon would be incapable of caring for, he is not likely to make a change. If his profits were more than necessary for the living expenses of himself and family he would probably spend the surplus for a passenger car rather than a new delivery vehicle. This is simply human nature and explains the enormous sale of automobiles to farmers, who do not buy tractors so freely.

The farmer is not alone in his inclination to continue using equipment which has proved adequate. It is nearly as difficult to sell new and improved machines to any other business man or manufacturer as to the farmer. It is only in newly built factories that the most improved machinery and equipment are found throughout. In older factories one is sure to find machines and equipment that are out-of-date and less efficient than other machines on the market. Hundreds of instances might be cited where large manufacturers are using

methods and equipment which are out-of-date and much less efficient than later methods; but, so long as the old equipment continues fairly satisfactory, it is used because the loss through sacrificing it to buy the newest and most improved equipment will often more than offset the slightly greater labor cost in operating the out-of-date equipment. Furthermore, manufacturers often take the attitude that the newer and more improved machinery will probably become cheaper, or that further improvements may be made that will justify waiting. Farmers are fully as well justified in taking this course. Most farmers, although they may have made a fairly large investment, are receiving such small returns that they cannot afford to risk a large amount in an experiment. They like to be as nearly certain as possible that any new machine they buy will return a good profit.

It is but natural that farmers watch very closely how their neighbors' tractors are working out. The tractor manufacturers should answer very frankly, to themselves at least, what has been the result of such observations. It is true that a high percentage of tractors bought within the last several years have proved satisfactory to their users. Most owners will say that the machines have been profitable, but in order to get to actual facts it is desirable that everyone realize just what these machines are actually doing for the men who own them. The farmer who is considering the purchase of a tractor should not be expected to take a particularly optimistic view and see things in a more attractive light than the facts actually warrant. He is rather critical of the performance of the machines, and the facts and figures as to what they have actually been doing certainly do not constitute a great incentive to hasten the farmer's purchase.

In advertising tractors and in attempting to emphasize their advantages over horses, the statement has been made repeatedly that the farm horse works on an average only about 100 days per year. This was intended to show that he was inefficient as a source of farm power and used only for field work, while the tractor could be used for belt work also. Figures obtained from tractor owners as to the number of days they use their machines for different kinds of work and as to the total number of days the tractor could be used each year, disclosed the fact that the tractor was generally used not to exceed 50 days per year and that on many types of farm it was used about half of this time at belt work. This was almost incredible to many people and its accuracy was questioned. Further investigation, however, showed that it was too high rather than too low an average.

### EFFORTS TO INCREASE TRACTOR UTILIZATION.

Some manufacturers, realizing that the tractor was being used so few days per year, that its work was largely limited to plowing and belt work and that horses were doing harrowing, disking, seeding and other operations following plowing, attempted to make the tractor more generally useful. They encouraged its use for practically all kinds of field operations, bringing out special harrows, disks, drills, harvesters and other machines to make the tractor more suitable for these operations. It was hoped that the perfecting of such machines for use with the tractor would result in its being used a much greater number of days annually.

Not many figures obtained within the past year are available to check up this expectation. Such as are available, however, do not indicate that the desired result has been accomplished. L. A. Reynoldson, of the office of farm management of the Department of Agriculture, visited 141 corn-belt farms where tractors were used in the summer of 1919, and obtained from the operators the number of days the tractor had been used in the different kinds of farm operation and also the time that horses had been used. These data differed slightly from most that had been obtained previously. Instead of taking the total number of days on which the tractor had been used for belt or field work, the owners gave as nearly as possible the number of full days the tractor had been used. If a farmer used his tractor 2 hours of 1 day each week to grind feed, instead of reporting the tractor used for 52 days for grinding feed, the figure would be 10.4 days. The investigation showed that tractors on the 141 farms visited were used only 29 days each year on the average. Horses kept by these tractor owners decreased, on an average, two and one-half per farm, while the average size of farm had increased 24 acres. The horses remaining on these farms were used an average of 78 days per year. For the average farm, 565 days of horse labor was distributed among the various operations in order of their importance, rated on the number of days' labor involved, as follows:

| | Days |
|---|---|
| Harvesting corn | 100 |
| Corn cultivating | 84 |
| Disking, harrowing, etc. | 71 |
| Road hauling | 63 |
| Hauling manure | 48 |
| Threshing | 44 |
| Plowing | 33 |
| Haying | 29 |
| Drilling | 25 |
| Cutting grain | 24 |
| Corn planting | 16 |
| Miscellaneous | 28 |

The neighbors of these tractor owners would not receive much encouragement from such tractor performance unless their owners were getting much better yields than farmers using horses or enjoying a greater profit by having their crops planted and harvested in season. These theoretical advantages, however, are not realized every season and the observer might not give them full benefit of their advantages along these lines.

Why do the farmers not make better use of their tractors? For an outfit costing $1,500 and used only 30 days each year, the interest charge alone would be about $3 per day, and depreciation, based upon a life of 10 years, would be $5 per day. One must admit that a farmer has much better reason to put off purchasing a machine which he can use only 30 days each year than a manufacturer has for postponing the purchase of an improved machine that he can probably use every day. The average size of the farms on which the 141 tractors mentioned were used was 346 acres, which is considerably higher than the average for the country or even for the corn belt. As would be expected, the number of days the tractors were used annually increased almost directly with the size of the farm. On farms of 220 acres and less, the tractors were used only about 20 days on an average, while on 380 to 700-acre farms they were used about 36 days. This merely reaffirms the fact that to utilize the tractor to advantage there must be enough acreage to keep it busy for a reasonable period each year. The number of days horses were used for various operations shows the need of developing more machines and attachments to make the tractor or truck suitable for the different kinds of work. For some, the motor cultivator will undoubtedly be used; for others, the truck will be more satisfactory than horses; for road hauling, hauling manure and probably some of the other work such as haying, corn harvesting, etc., the truck will have its place.

Granting that the sale of tractors has not been all that could be desired and that this condition can be improved upon, the principal question is how to overcome the obstacles which have interfered with the development of the business, so that the tractor will be generally adopted for farm work. First, the initial cost of a tractor must be such as to make it practicable for a business of the magnitude of a large percentage of farms. Second, it is obvious that what is commonly termed intensive cultivation, meaning the growing of crops by hand methods on small areas, does not tend to increase the sale of large machines of any kind, tractors, included. But extensive farming, the raising of crops on a large scale with a minimum of human labor through the use of large labor-

saving machines, does tend to encourage the use of all kinds of improved equipment, including tractors. Less consideration should be given to 10-acre farms and more to 1,000-acre farms; the latter can use tractors to advantage; the former cannot. The problem will solve itself if things are allowed to take their own course, or the solution can be hastened by proper action. At present, farmers receive advice on practically every subject connected with farming except on the use of labor-saving machines. All kinds of experiments and investigations are being carried on in the breeding of live stock and better crops; likewise, experiments in the building up and maintenance of soil fertility are being carried on in great number. Such detailed information can be obtained by any farmer who wishes it, but regarding information as to the best crop rotation and acreage to make use of a tractor efficiently, little is available.

It is unreasonable to expect each individual farmer to be capable of working out an organization and crop rotation for his farm which should make it possible and practicable for him to use a tractor. He is not much more likely to do this than he is to breed a better variety of wheat by hybridizing. Some individuals will solve their own problems of this kind. The large percentage of tractor owners who enlarge their farms and increase their returns by a better farm organization on an extensive scale are ample proof of this. What is needed is to ascertain just exactly how these successful users have reorganized and to pass this information on to other farmers. Organizations are now teaching farmers how to treat their hogs for cholera, how to fumigate seed and inoculate soil and are giving other information which adds to general prosperity. The farmer should be told how to change over from a small and inefficient plant where human labor is being wasted, to a larger and efficient food-production organization, on which he can practise the same principles of quantity production as are practised by large manufacturers today. Farming needs to be put on a quantity production basis fully as much as does any other industry for the good of the individual farmer and of the country as a whole.

# More About High Flying*

## Aerial Leviathan with Enclosed Cabin Especially Adapted for Flight at High Altitudes

By Dr. Guglielminetti

President of the Section of Physiology of the International Aeronautic Exposition

[*Note.—In the January number of this magazine we published, under the title Aerial Travel at High Altitudes, an article giving some account of the work done by Dr. Guglielminetti, with respect to the physiological aspect of balloon or aeroplane travel at great heights. The latter part of this article dealt with the devices known as "aerial diving suits" and "submarines," but without going into details. We are now fortunate enough to be able to give our readers further data upon this interesting subject in an article from the pen of Dr. Guglielminetti himself. We omit the first part of the present article since it deals with the physiological studies described in our January number.*—THE EDITOR.]

HAVING thus considered the physiological basis of our problem we shall now undertake to describe the apparatus by means of which oxygen can be furnished to pilots or passengers at high altitudes. These include individual inhalation apparatus and closed cabins with the contained atmosphere at a constant pressure.

### RESPIRATORY APPARATUS FOR INHALING OXYGEN.

Great improvements have been made in respiratory apparatus since the time of Paul Bert. Rubber balloons have been replaced by steel tubes containing oxygen at a pressure of 150 atm. It was when upon Mont Blanc that I conceived the idea of providing these tubes with decompressors for the purpose of regulating the flow of oxygen per liter and per minute. Thanks to apparatus of this kind, Messrs. Jacques Balsan and Louis Godard were able in 1900 in a free balloon to reach the altitude of 8,600 m. (28,200 ft.), the same altitude at which Crocé-Spinelli and Sivel, 25 years earlier, had perished from suffocation in spite of their supply of oxygen. Balsan commenced the oxygen inhalations at a height of 4,000 m. (13,100 ft.); nevertheless he told me that it became hard for him to work by the time he had reached 6,000 m. (19,680 ft.); he was suffering pain and was no longer able to place the mouth of the pipe connected with the oxygen tube in his mouth; Godard quickly handed him the pipe and in a couple of minutes he felt better; then Godard, in his turn, began to find it impossible to act.

It is absolutely necessary that upon reaching a given altitude the inhalations of oxygen should continue without interruption, consequently, these pipettes at the end of tubes connected with the oxygen supply are scarcely practical since they must be held in one hand which is a difficult thing to do during the maneuvering of the balloon. For this reason they were replaced by masks covering the mouth and nose of the aeronaut in such a manner as to enable him to breathe the oxygen automatically, starting at a height of about 3,000 m. (9,840 ft.) so as to prevent an attack of illness. Provided with these masks Messrs Bienaimé, Jacques Schneider and Senoucque reached a height of 10,108 m. (33,163 ft.), this being the French record, while two Germans, Messrs. Berson and Suhring achieved the world altitude of 10,800 m. (35,433 ft.) in 1911.

During the war the French Technical Aeronautical Service perfected the decompressor of these apparatus, whose flow is now regulated by the height of the atmosphere: The percentage of oxygen automatically increases as the aviator ascends and diminishes in the same proportion as he descends. The flow is controlled by a barometric chamber and regulated in function of a decrease of temperature proportionate to the altitude in accordance with the law formulated by Radau.

In 1919 Casale, provided with such an automatic apparatus, reached a height of 9,500 m. (31,170 ft.) in full possession of all his mental and physical powers. This is the world record in a *homologated* aeroplane; the American aviator, Major Schroeder is stated to have reached a height of 11,000 m. (36,020 ft.) with a barometer, which was verified but not *officially homologated.*

Dr. Schroetter of Vienna informs us that his handwriting became almost illegible at a height of 6,000 m. (19,680 ft.), but became normal after a few respirations of oxygen, and a sphygmographic record, taken in a balloon, at 7,500 m. (24,600 ft.) height was absolutely normal, thanks to the oxygen which had been breathed beginning at a height of 5,000 m. (16,400 ft.), whereas, a record of the pulse beat taken at a given altitude (without oxygen) always exhibits marked peculiarities.

Thus we see that hitherto not more than five or six men can boast of having exceeded an altitude of 10,000 m. (32,800 ft.) i.e., of having penetrated the stratosphere: three Frenchmen, one American and two Germans. The last mentioned reached a height of 10,800 m. (35,433 ft.), but in an actually paralyzed condition, incapable of sufficient energy to make the slightest motion. It took all their energy to conquer an almost invincible sleepiness in spite of the oxygen they breathed. As soon as they ceased taking oxygen for a few

*Translated for the *Scientific American Monthly* from *Le Génie Civil* (Paris), March 20, 1920.

minutes the palpitation of the heart increased and they commenced to stagger.

It would seem, therefore, that 11,000 m. (36,000 ft.) is the final limit at which life is still possible, even by means of artificial inhalations of oxygen. This agrees with the results obtained in the pneumatic bell jars of laboratories which show that at a decrease of pressure corresponding to 12,000 m. (39,370 ft.) of altitude, the tension of the oxygen in the lungs falls so low that the tissues are unable to make use of it. The pressure is so low in fact that it seems that the blood is no longer able to absorb sufficient oxygen and asphyxiation ensues. Why was it that inhalations of oxygen failed to save the life of Dr. Jacottet upon Mont Blanc? The oxygen apparatus was not as perfect at that time as today, but it is possible too, that an insufficient supply of oxygen gradually produces, because of incomplete oxidation, toxins which are difficult to eliminate and which, therefore, produce a sort of intoxication.

But is it possible to ascend still higher, in other words, to render respiration possible at a height greater than 11,000 meters? The Italian School of Physiology believes that it is. According to Professor Mosso of Turin, the well-known author of the work *L'homme sur les Alpes* (Man in the Alps), carbon dioxide escapes from the blood in such abundance at high altitudes as to result in impoverishing the bodily supply of this gas, thus occasioning an interference with the proper functioning of the nerve centers which regulate the heart and

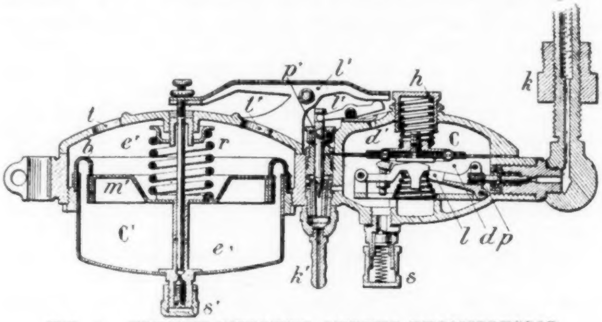



FIG. 1. SECTION THROUGH OXYGEN DECOMPRESSOR AND THE BAROMETRIC GOVERNOR

respiratory organs. This phenomenon has been termed by Mosso *acapnia;* this theory differs from that of Paul Bert, according to whom it is *anoxyhemia*, the lack of oxygen which causes the said disturbances.

Believing the theory of Mosso to be correct, Professor Agazotti was able to subject himself, thanks to a mixture consisting of 13 per cent of carbon dioxide and 67 per cent of oxygen, to a pressure of 122 m. in a pneumatic bell jar—a pressure corresponding to an altitude of 14,850 m. (48,720 ft.). Monkeys placed in the same conditions were able to support a decompression as low as 100 mm. (3.937 in.), corresponding to a height of 16,000 m. (52,490 ft.).

Carbon dioxide, like nitrogen, is of no value for respiration; it does nothing but dilute the oxygen which is the only gas required to support life; but it has been found that carbon dioxide has the property, as yet unexplained, of considerably increasing the pressure of oxygen in the blood. Since the expansive power of carbon dioxide is 2½ times as great as that of oxygen, it is possible that the pressure of the oxygen in the lungs may be increased by the presence of the carbon dioxide. This appears to agree with observations made in the laboratory, which prove that when the air is very greatly rarefied the blood retains a portion of the carbon dioxide produced by the respiration in order to facilitate the absorption of rarefied oxygen. It is possible, therefore, as has just been pointed out by Dr. Garsaux that both the French theory and the Italian theory are quite correct, one being valid at a height of about 8,000 m. (26,250 ft.) and the other at a greater altitude.

In my opinion the results obtained by these laboratory experiments are absolutely conclusive with respect to flights at high altitudes, and I believe that it is not impossible that still greater altitudes can be attained than those hitherto recorded by means of mixures of these two gases. Without going so far as that our military aviators were able to operate during the war, as a matter of current practice, at altitudes of from 5,000 to 7,000 m. (16,400 to 22,960 ft.) and it was necessary to provide them regularly with respiratory apparatus consisting of an oxygen flask with a decompressor controlled by a "barometric capsule." The details of such an apparatus are shown in Fig. 1.

The oxygen reservoir contains a little more than 2 liters of water or 350 liters of gas at a pressure of 175 kg.; when necessary several of these are installed parallel to the decompressor. The latter is mounted upon the neck of the reservoir and comprises two chambers: The chamber C forming the decompressor properly so-called, and the chamber C', known as the barometric controller.

The decompressor is made of aluminum and is divided into two chambers; the lower one *d* is the expansion chamber and contains a system of levers *l* which by means of a needle valve *p* open and close the inlet orifice of the gases at high pressure. A safety valve *s* is connected with it. The higher one *d'* contains a spring regulating the pressure and controlled by the band of the cap *h*. The membrane *m* is composed of rubber cloth, armed with a central washer of copper and guided by a rod. The gas arrives by way of the coupling *k* and the valve *p*, the latter being controlled by the levers *l*, and then traverses the compartment *d* and passes into the respiratory masks of the pilot, observer, etc., by means of the coupling *k'*, which may have several branches.

The barometric chamber is likewise divided into two compartments *e* and *e'*: the top one communicating with the outside by means of the holes *t* is subject to the depression due to the altitude, while the lower one *e*, which is entirely closed, takes and maintains the pressure at the level of the ground, thanks to an equilibrium flap-valve *s'*. The copper disk *m'* is subject, therefore, to the difference of pressure, and thanks to the annular rubber band *b* is displaced by the action of the spring *r* in proportion as the pressure of the atmosphere diminishes; this movement, amplified by the system of levers *l'* bears upon the valve *p'* which regulates the flow. Hence the latter increases automatically with the altitude.

From the coupling *k'* the gas reached the mask worn by the aviator by means of a flexible tube; the mask consists of a small aluminum cap whose contours follow the shape of the nose and mouth. At the bottom there is an orifice which serves to allow normal respiration and for the evacuation of condensed water vapor. The edge of the mask is inserted into a hollow rubber rim, so as to fit closely to the face. The oxygen enters through a perforated tube which diffuses the gas upon each side of the nostril.

The oxygen flasks must be placed as far as possible from the gasoline tanks. The installation is completed by a "flow-controller," a small drum placed in a glass sided box under the eye of the aviator, and inserted in the system of pipes between the expander and the mask: the rotation of pallets, under the effect of the gaseous current, assures the aviator that the apparatus is functioning properly.

### STUDY OF A CLOSED CABIN, AT CONSTANT PRESSURE, FOR AERIAL VOYAGES AT HIGH ALTITUDES.

Because a few bold aeronauts, provided with respiratory apparatus have been able to attain high altitudes, and because during the war courageous military aviators were able to ascend into these regions in order to be above their adversary, are we justified in concluding that the same thing could be done by passengers in general? By no means![1] All these "record men" were men trained to sport or else young pilots

[1]This is also the conclusion stated in a communication with Dr. Garsaux, based upon his decompression experiments in the pneumatic caisson of the technical section of Aéronautics at St. Cyr. *Vide* a note in *L'Aérophile* (Paris), June 1 and 15, 1919.

selected after severe tests to which passengers could hardly be subjected. Even aside from the rarefaction of the air there is another danger at high altitudes, namely, sudden variations of pressure, but it might well happen that among the passengers there would be present those suffering from maladies or weakness of the heart and arteries, to whom great variations of pressure might be fatal. Without wishing to discourage passengers who wish to make use of this new mode of transport, it is the duty of the physician not only to second the progress of science but also to draw attention to possible accidents in order that they may be avoided.

The solution which naturally occurs to the mind is to entirely remove, not only the passengers but likewise the pilot and even the motors from the pernicious effects of the atmospheric depression, by enclosing them all in an air-tight cabin, a sort of huge collective diving suit. This idea has already been elaborated in every detail as we shall show a little further on.

It is interesting from a historical point of view to recall that even fifty years ago various projects were proposed for enabling mankind to navigate the air in balloons at very high altitudes. In 1871 Louis Tridon presented before the French Society of Aeronautic Navigation a project for a *closed car*[2] composed of solid portions and flexible portions. The solid portions comprised two platforms, a "ceiling" and a "floor" made of willow; the upper platform acting as a maneuvering car. When at a high altitude the aeronaut was supposed to descend by a manhole into the lower car which contained flasks of oxygen and cloths saturated in lime water to absorb the carbon dioxide produced by respiration.

In 1900 M. Andrieux presented before the same society a plan for an *aerial diving suit*[3] designed to enable the wearer to reach the loftiest regions of the atmosphere without danger. This so-called diving suit consists of a costume of impermeable cloth. A special system of tubes supplied by an oxygen tank is supposed to maintain around the aeronaut a sufficient pressure to cause the proper circulation of air and ensure good respiration.

Since that time mankind has succeeded by means of such apparatus, of diving bells, diving suits, and submarines, in living within a medium which provides no means of respiration in itself. In an analogous manner the airplane or the dirigible might comprise a closed cabin, in which the atmospheric pressure at the ground level could be kept constant by means of a pump drawing in air from the outside, within which would be contained an indefinite amount of oxygen, which would merely have to be compressed. This same pump would also furnish the necessary supplement of air to the motor, since the motor like the man needs more air at high altitudes. For this purpose M. Reatau advises the use of a turbine driven by the exhaust gases of the motors, which is a very rational idea.

In this manner the passengers would not only be protected against the rarefaction of the air, but also against sudden variations in temperature. There would be no special difficulty in heating and ventilating such a cabin.

Such a cabin would be far easier to construct than a submarine, since its walls would not have to support such a heavy pressure. The difference of pressure between the internal and external air would not exceed one-half atmosphere at the loftiest altitudes, while submarines often have to withstand pressures of three or four atmospheres. Furthermore, a breach in the walls would be by no means so dangerous as such a breach in the hull of a submarine: It would always be possible to remedy it temporarily by means of the compression pump, while descending to a lower altitude.

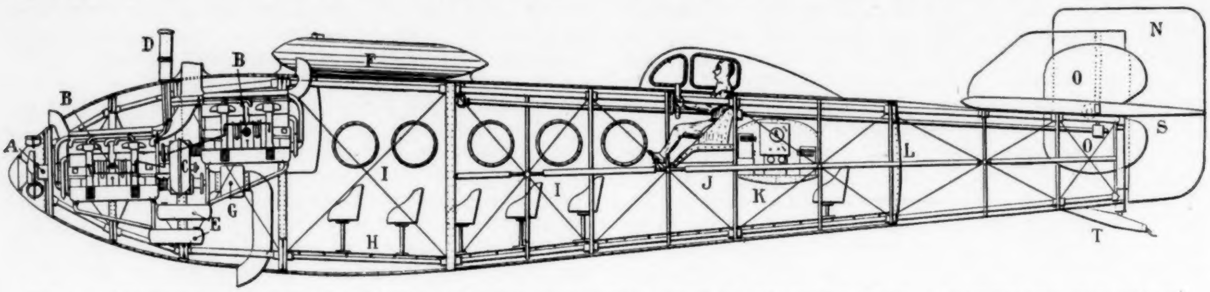



FIG. 2. LONGITUDINAL SECTION OF THE BRÉGUET LEVIATHAN, TYPE 20, PROVIDED WITH A COMPRESSOR FOR FLIGHT AT HIGH ALTITUDES

*A*, propeller shaft; *B*, Bréguet-Bugatti motor; *C*, clutch; *D*, radiator; *E*, oil reservoir; *F*, gasoline tank; *G*, turbo-compressor; *H*, lower wing; *I*, passenger cabin; *J*, controls; *K*, radio station; *L*, airtight partition; *N*, rudder; *O*, fixed lateral planes of rudder; *S*, elevator; *T*, skid.

Figs. 2 to 4 show sections of the plan devised by the well-known airplane builder, Louis Bréguet, for an aerobus for use at high altitudes. The caption of Fig. 2 sufficiently explains the general arrangement. We may add a few remarks concerning certain features of the construction and method of functioning.

This biplane, which has been named the Leviathan, weighs about 2,500 kg. empty, or about 1,500 kg. for the motor part and only 1,000 kg. for the plane itself. It has a spread of 26 meters, a length of 14 meters and a surface of 140 square meters. It is built entirely of metal having a broadly calculated solidity and an exceptional lightness not hitherto attained.

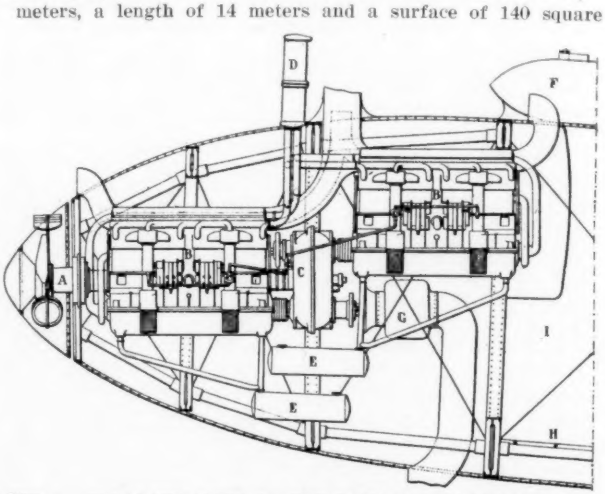



FIG. 3. ENLARGED VIEW OF THE BOW OF THE BREGUET BIPLANE

In order to withstand an accident to the motor without fear of forced landing, the motor power of 950 hp. has been divided among four eight-cylinder motors.[4] These motors, grouped

[2]See *Scientific American Monthly*, Jan., 1920, p. 50.

[3]Ibid.

[4]This group was exhibited at the last *Salon de l'Aéronautic*, where it attracted much attention; it was reproduced in *Le Génie Civil* for January 10, 1920, p. 31.

in a space big enough to be called a room, drive the same propeller. When a motor has an accident it is immediately thrown out of gear automatically and the biplane continues to fly by means of the three other motors. Thanks to the large dimensions of the "machine room" the mechanician can move about at ease having ready access to all parts of the motors, and thus is able in most cases to repair the damage, which is usually due to some trifling cause such as sticking of the spark plugs, the breaking of an axle rod or valve spring, the stopping up of a pipe, etc. Thus such a biplane can be repaired while flying, like a dirigible. Even with two motors not working, the flight of the avion would merely be somewhat slightly in a descending direction.

Furthermore, the single central fuselage enables the pilot to enjoy the advantage of excellent aerodynamic properties and ease of manipulation: the central propeller does away with the swerving so dangerous for the pilot, which occur in planes having multiple propellers when a side propeller stops suddenly.

The accompanying diagram (Fig. 5) indicates the possibilities in the Leviathan's progress, the variations in its radius of action and its "ceiling" in function of the loads carried and the amount of fuel taken along. Here we may read for example that if we fix upon a ceiling of 6,000 m. (19,680 ft.) we can transport a total load of 3,200 kg. (7,055 lbs.). If to this load we add 2,000 kg. (4,409 lbs.) of fuel we read upon the upper scale opposite the vertical line at the point *b* the possible distance of transport 3,100 km. (1,926 miles) and upon the lower scale the value 0.35 of the ratio $\frac{Q}{P}$ of the weight of fuel carried to the total weight at the starting point. The latter 5,700 kg. (12,566 lb.) is read upon the vertical scale at the right at the side of the scale of *total loads*. These run in practice up to five tons: with a single ton the ceiling is 9,000 m. (29,530 ft.; even with five tons it is still 3,500 m. (11,480 ft.).

According to the proportion in which the total load is divided between the fuel and the useful weight, i.e., passengers, cargoes, or bombs, we shall have an avion carrying a limited useful load to a great distance, or a much larger useful load to a much shorter distance. If, for example, the distance to be covered is but 1,000 km. (620 miles) as from Paris to Madrid, with a ceiling of 4,500 m. (14,760 ft.) the plane could

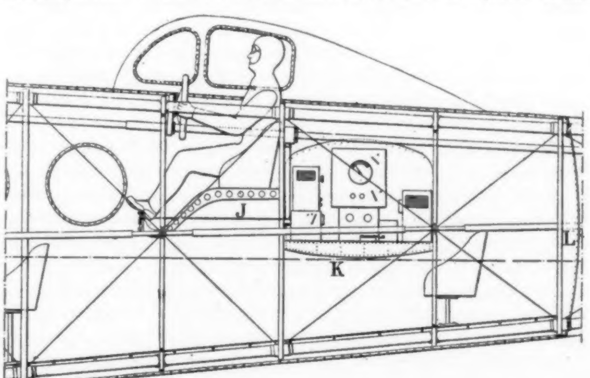



FIG. 4. SECTION SHOWING THE PILOT'S HOOD

carry a total load of 4,200 kg. (9,260 lb.), 800 kg. (1,760 lbs.) of fuel would be a sufficient supply which would leave a useful load of 3,400 kg. (7,500 lb.) (or 27 passengers, each with an allowance of 40 kg. (88 lb.) of baggage); the voyage could be made in five hours and a half.

If, on the contrary, a long cruise was in question, for which the minimum ceiling would be put at 3,000 m. (9,840 ft.), 5.2 metric tons (5.73 short tons) of total load could be carried. Such a load might comprise, for example, the following items: 1 metric ton of useful weight (five men in the crew, instruments, supplies) and there would remain 4,200 kg. (9,260 lb.) for the possible fuel weight; this would allow a voyage of 5,000 km. (3,100 miles) in a calm in 28 hours of flight, at 180 km. (112 miles) per hour, or with a steady head wind of 30 km. (19 miles) per hour we would still be able to travel more

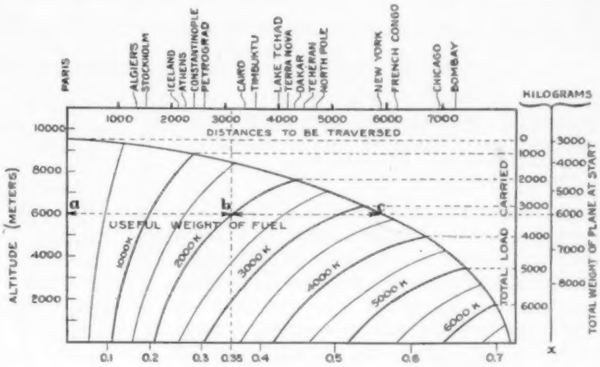



FIG. 5. CHART OF CAPACITY AND RANGE OF THE BREGUET BIPLANE

The scale of the abscissae $x$ represents the ratio Q/P, i.e. the weight of the fuel consumed divided by the total weight at the start.

than 4,000 km. (2,480 miles), in other words the distance which separates Paris from Lake Tchad, from Dakar, or from the American continent (Newfoundland).

In seeking the practical limit of the maximum distance which it is possible to cover, we find that a crew of three men consisting of two pilots and a mechanician plus the necessary provisions (about 500 kg. or 1,100 lb.) would be able to carry 4,700 kg. (10,360 lb.) of gasoline and fly *for* 38 *hours* at 170 km. (106 miles) per hour, thus covering a distance in a calm of 6,500 km. (4,039 miles) or more than the distance which divides Paris from New York, from the French Congo, or from Lake Victoria.

It is extremely probable, therefore, that within a few years at most we shall be traveling over the invisible roads of the stratosphere at velocities of more than 300 km. per hour.

## A FOG ELIMINATOR FOR MOTION PICTURE STUDIOS.

EVERYONE who has ever seen a typical London fog of the "pea soup" variety knows very well that its murky yellow obscurity not only makes traffic impossible in the streets, but inevitably invades houses in spite of artificial light. It is impossible to take clear studio pictures in such an atmosphere. Formerly there was nothing to do but to stop the work of the cameras until the air cleared up. It is now reported, however, that a well-known motion picture firm, the Famous Players-Lasky British Producers, Ltd., has found a method of obviating this difficulty in its London studios, situated at Islington.

The fog eliminator is described as being composed of a series of high and low pressure coils installed at points of vantage around the big stages. One side of the building carries a series of high pressure coils along the entire length of the stage. On the opposite side a little higher up on the wall, is a series of low pressure coils. The roof contains other high pressure coils and a large exhaust fan.

On entering the studio the fog encounters the high pressure coils and is thrown up to the ceiling, where it is taken in charge by the other high pressure coils and the exhaust fan, and is quickly dissolved, or at any rate eliminated as a factor in interfering with the cameras.

Experiments conducted several weeks ago by the studio staff have demonstrated the complete success of this method of treating even the heaviest of London fogs; even when it is not possible to disperse the fog entirely, its heavy blanket can be lifted to a height of 15 or 16 feet above the floor of the stage, thus enabling the directors to go on working.

# Science and National Progress

## Edited by a Committee of the National Research Council

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## FOG AND SMOKE.

By Wilder D. Bancroft.

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A FOG consists of drops of liquid suspended in a gas, usually air, while a smoke is composed of solid particles. Fogs are formed outdoors when moist air is cooled beyond the saturation or dew-point, but not enough to precipitate in large drops as rain. Fogs are more frequent at the sea-shore than inland because the air above the ocean is more nearly saturated as a rule than on the land and consequently fog forms readily when the temperature drops. A striking case of this is the fog which comes rolling in from the sea at San Francisco on summer afternoons. We speak of the sun burning off the fog; but that is purely figurative. What happens is that the drops of water evaporate. They will start to do this normally as soon as the temperature rises above the dew-point. Under special conditions we may get what are known as dry fogs, for dense fogs have been noticed around London when the air was only about half-saturated. This is probably due to films of oil from coal smoke which coat the drops of water and retard the evaporation.

Everybody is familiar with the fact that the steam issuing from the spout of a tea-kettle condenses at least temporarily to fog and one of the laboratory methods of producing fog is to let a jet of steam emerge into a cooler atmosphere. The condensation of water vapor from the breath on cold days is another case of the same sort and shows that the important thing is not the initial temperature of the steam jet. Many people think that the water in a kettle is boiling when they see the steam from the nozzle condensing to fog; but this is not always the case. It is not necessary, however, to lift the lid in order to tell whether the water is boiling. If the fog rises vertically, the water is simmering. When the water boils, there is more pressure and the fog forms a curved line.

By taking special precautions it is possible in the laboratory to cool water somewhat below the freezing-point without any ice being formed. This is more difficult the larger the scale, but it occurs on Mt. Washington at times when a southerly wind brings up a drifting fog. When the temperature of the air and of the ground is below freezing, this fog deposits feathery crystals of ice on every surface that obstructs its passage, forming what are known as frost feathers. A round post will have an almost uniform crop of crystals on its windward half, pointing so accurately to windward that it is possible to trace changes in the direction of the wind from the successive layers of crystals lying at different angles. The rate of growth varies with the density of fog and the speed of the wind. A rough average is half an inch per hour and two inches per hour seems to be a maximum value. The phenomenon is what one would expect from liquid particles cooled below the freezing-point.

These supercooled fogs are quite different from the so-called ice storms which occur once or more every winter and which sometimes do so much damage to trees. In the ice storms the moisture deposits as liquid water on the branches and twigs, freezing there to solid ice. These storms occur when the temperature is below freezing and a warm rain or mist comes down from above without getting chilled to the freezing-point before it strikes the trees.

While fog is due to the production of very small drops, rain is due to the formation of larger drops which fall with perceptible speed. There is no absolute dividing line between the two because most people would classify as rain what a Scotchman might call a mist. According to the Weather Bureau, rain appears to begin when the drops reach a diameter of 0.04 millimeter. The maximum rate of fall of these drops is very small. Larger drops fall faster. According to Lenard, drops of about 1.3 millimeter have a final velocity of 4.8 meters per second, those with a diameter of about 3.5 millimeters reach a velocity of 7.4 meters per second, while drops from 4.5 to 6.5 millimeters show a practically constant rate of about 8 meters per second. This limiting value is due to the drops becoming deformed, so that they become flattened out, instead of retaining the shape of spheres. They, therefore, offer an increased resistance to the air through which they fall. In consequence of this deformation large drops break up rapidly in the air into smaller drops. Lenard found that drops of 4 millimeters diameter were stable under all conditions, but that drops of 5.5 millimeters diameter and over could not exist for more than a few seconds after attaining their final velocity relatively to the air. This is in harmony with the results of other observers. Wiesner concluded that natural rain drops cannot have a diameter larger than 7.2 millimeters, while Ritter found that the largest drops of natural rain did not exceed 6.6 millimeters diameter. An independent confirmation is found in Bentley's experiments on the size and frequency of drops during rains in northern Vermont. He found that over 60 per cent of the rain drops were between 0.8 and 3.5 millimeters in diameter and he observed none larger than five millimeters or about two-tenths of an inch.

The fact that large drops break up into smaller ones after they reach a certain speed has been used by an Englishman in India named Simpson as the basis for what is at present the most generally accepted theory of thunderstorms. Simpson assumes that in thunderstorms we have a rapidly ascending current of air which spreads out above a certain height and consequently slows up. Large rain drops will fall through this air curent until they reach a point where they are broken into smaller drops and are then carried to the upper and colder levels where they grow again and repeat the cycle. When the drops break up they become charged positively while the negative ions are carried up more rapidly by the air and are finally caught by cloud particles at some higher level. On this hypothesis positively charged rain should fall in bursts in the center of the thunderstorm while negatively charged rain should fall in the lulls and on the outskirts of the thunderstorm. This actually happens. Simpson satisfied himself that the electricity generated by the breaking up of the falling drops might easily account for the gradient of 30,000 volts/cm necessary for lightning. Unfortunately Simpson does not discuss the question as to the minimum size of thunderstorms. It would be of great assistance to the study of meteorology if we could have a synthetic and dwarfed thunder-

storm in the laboratory by starting with a vertical blower and a watering-pot.

The optical properties of suspended drops of water are very interesting, the best known case of this being the rainbow. When direct sunlight falls upon a transparent sphere, such as a rain drop, some of the light is reflected from the surface and some of it passes into the drops where it is split into its constitutent colors by refraction. After one or more reflections at the internal surface of the drop, the colored light passes out again. Under most conditions this light is divergent sooner or later and consequently is soon spread over such an area as to be practically imperceptible. At certain angles the light leaves the drop as a practically parallel beam, and it is these nearly parallel rays which give rise to the single and double rainbow. Since the rainbow appears along the circumference of a circle whose center is on the straight line connecting the sun with the eye of the observer, no two persons really see the same rainbow. One man sees the light from one set of drops and another sees that from a different set. For a similar reason the rainbow that one sees reflected in the water is not, strictly speaking, the same rainbow that one sees by looking at the sky, though in these cases the substitute is exactly as good as the original. When the rainbow is double, the inner and brighter one is due to light that enters the upper half of the drops and comes out from the lower after one internal reflection, while the outer and fainter rainbow is due to light which enters the lower portions of the drops and comes out from the upper portions after two internal reflections. The double reflection reverses the colors so that the red is on the inside and the violet on the outside, instead of the other way round as in the primary rainbow.

When the sun shines on fog or mist, a fog-bow is often seen which may be four times as broad as the ordinary rainbow, but which is not so bright in color. The size of the bow depends on the size of the drops, the diameter of the bow being less with very small drops than with large ones. The cloud effect known as the Specter of the Brocken is so-called because it is often observed on the mountain of that name in Germany. It is seen when the sun casts a giant shadow of the observer on a fog bank across the valley, the fog-bow forming a circle of glory round the specter's head. Similar but more brilliant glories are observed when an aeronaut in a balloon sees his shadow projected upon the top of a cloud, these glories being more perfect than those seen on the mountains because the drops in the upper portions of the clouds are apt to be more uniform in size.

Most people are familiar with the colored corona surrounding a bright object when seen through spectacles covered with fine drops of moisture. The colors are due to diffraction by the spherules of water. Under suitable circumstances we may see coronas surrounding the sun and such circles may be seen around the sun on almost any day of the year if we view the sun from some poorly-reflecting surface like water in order to eliminate the blinding glare of the sunlight. In order to have the formation of a well-defined corona, it is necessary that the drops should be exclusively or chiefly of one size. By measurement of coronas it is possible to infer the size of the drops which give rise to them because the corona is larger the smaller the drops. This method has been used to determine the diameters of the drops of water forming clouds.

A cloud is a mass of dense fog. Since the sunlight is scattered from the surface, the cloud normally appears white. If, however, the clouds are illuminated chiefly by the red and yellow rays from the setting sun, all sorts of colors may be observed. The upper part of a tall cumulus is often a delicate pink, while the lower portion is ashy gray; and below that the blue and green sky tints may be visible. A decided pink or straw-colored yellow is often seen when looking at the dazzling white on the sunny side of a cumulus cloud. Apparently the surface particles of the cloud are being evaporated in the sunshine, and the adjacent layer of air is supersaturated with moisture at a relatively high temperature; possibly minute particles of water are present and modify the orange and pink tints that are spread in spots over the cloud. The tints are seen only when cumuli are sending up great thunderheads like explosions of steam boilers.

Still another color phenomenon is associated with the under sides of cumulus clouds, as in approaching thunderstorms, when the landscape beyond the cloud is brilliantly lighted by the sunshine; in such cases the observer may see patches of yellow or green on the lower side of the cloud, being light from the bright landscape beyond, reflected by the big drops.

As an intermediate stop between fog and smoke we have the precipitation of water vapor in solid form as snow, sleet or hail. When the dew point is decidedly below freezing, water vapor condenses directly to crystals of ice, ice needles, or snow flakes. When supercooled rain drops strike solid substances they cover these with a coating of transparent ice. When snow crystals and supercooled rain drops come in contact we get sleet and sleet changes to hail when the supercooled drops precipitate in the form of sheaths of ice. In order that hail stones should grow to any appreciables size, they must be carried up and down a number of times. Even in midsummer the temperature six kilometers above the earth's surface will be at least —26°C. and may easily be —40°C. The reason that we get hail chiefly in summer is because then we have the hot air at the earth's surface giving a sharp temperature gradient and therefore a rapid upward sweep. The warm air may contain a great deal of water vapor which permits the formation of a large formation of ice. In winter the vertical temperature gradient is less and also the amount of water vapor in the air. Consequently, we get no real hail, especially far from the sea.

There is no especial difficulty in forming a fairly good pictue of the way a hailstorm is formed. The structure of the hailstone gives us some clues. Round a cloudy opaque center, something like sleet, there are transparent shells of ice arranged more or less like the coating of an onion. These are often full of air bubbles and appear partly white. Trabert has pointed out that a hailstone seems to contain three kinds of ice; the center of frozen snow; the concentric sheaths of ice; and occasionally clear, even crystalline, ice on the outside, though in very many cases this last form cannot be detected.

What takes place in the hailstone from the inside to the outside takes place also in the clouds from above to below. In the uppermost portions of the clouds we have snow crystals and supercooled drops; in the lowest portions only the ordinary mist at a temperature not much above the freezing-point. The upper region furnishes the center of the hailstone; the middle one the concentric sheaths of ice; and the third the material of the more or less crystalline deposits gradually formed on the hailstone. In fact, the hailstones often reach the earth while their temperature is far below the freezing-point.

Hailstones can only form if they are supported during formation by strong ascending currents. Further, the structure of a hailstone indicates that it is often carried up and down past the zero isothermal. Now, a current of air sufficiently strong just to support a hailstone as big as a pea would be more than sufficient to carry up the water it condenses within itself; hence, hailstones would always have a greater downward velocity relative to the ascending current than the water in the current and there would be a large amount of splashing between the two. There would be, consequently, a much greater amount of separation of electricity than would have taken place without the hailstones, and this might very well account for the great violence of the electrical discharges in hail storms.

Unless subjected to special treatment, the air always contains dust. The air of large cities invariably shows hundreds of thousands of dust-motes per cubic centimeter, that of the village or town thousands, and that of the open country at least hundreds. The dust may be soil from the fields and roads, particles of animal or plant origin, including pollen,

products of combustion, salt from the spray of the ocean, volcanic dust, or cosmic dust. The dust from the eruption of Krakatoa was shot high into the air and was carried entirely round the world, falling on the decks of ships and on various parts of the earth. Owing to the enormous distances to which volcanic dust may be carried, it is necessary to have some definite test before we can say that a given sample of dust is really cosmic dust coming from meteors which have burned up in passing through the earth's atmosphere. This matter has been studied by Hartley and Ramage, who collected numerous samples of dust in the neighborhood of Dublin and examined them spectroscopically as well as other samples furnished by friends.

The astonishing thing about the results was the number of different elements found in the dusts from different sources. In flue dusts from chemical plants, copper smelters and iron furnaces, it was not surprising that lead, silver, copper, nickel and manganese should be present in relatively large proportions; but nobody was prepared to find rubidium, gallium, indium and thallium in all samples. The nature of soot from different sources is characterized by the small proportion in most specimens of iron and of metals precipitated from hydroxides; its large proportion of lime and the greater variability in the proportions of its different constituents distinguishes it from other kinds of dust collected from the clouds or in the open air. It was unexpected when nickel, calcium, manganese, copper, and silver were found to be constant constituents of soot from different chimneys. It is interesting to note that in Dublin there is more lead, copper and silver in the soot from a laundry chimney than from a bedroom chimney.

The principal characteristics of dust which has fallen directly from the clouds or has been collected by hail, snow, sleet, or rain is its regularity in composition—each specimen appears to contain the same proportion of iron, nickel, calcium, copper, potassium, and sodium. There is a very considerable difference between the dust from sleet, snow, and hail suddently precipitated, the difference being in the proportion of lead, which, in the dust from sleet, is much larger than in the other specimens, though dust from hail and one quantity collected from rain contains more than is found in any other specimen with such an origin.

Hartley and Ramage believed that dust which fell on the night of November 16, 1897, might have been of cosmic origin but the evidence is not very convincing. This dust fell for the most part on a perfectly calm, fine night and there was no rain for twenty-four hours or more afterward. Since then no one has apparently been interested in detecting the fall of cosmic dust in his own back-yard.

In 1884 the problem of precipitating smoke electrically was studied by Sir Oliver Lodge, who has recently been lecturing in this country on psychic research. Lodge found that with a potential difference of several thousand volts, alternating current, and a brush discharge, the smoke agglomerated and settled rapidly, but neither he nor anybody else has really worked out the theory of the action. The process is too slow to be useful with the large masses of rapidly moving smoke as it comes from a stack and it was only through the much later work of Cottrell, now Director of the Bureau of Mines, that the electrical precipitation of suspended particles has been put on a commercial basis. Cottrell made use of a high tension direct current.

If a needle point is connected to one side of a high-potential direct-current line opposite to a flat plate connected to the other side of the line, the air space between becomes highly charged with electricity of the same sign as the needle point irrespective of whether this is positive or negative, and any insulated body brought into this space instantly receives a charge of the same sign. If this body is free to move, as in the case of a floating particle, it will be attracted to the plate or opposite charge and will move at a rate proportional to its charge and the potential between the point and the plate. Even if there are no suspended particles the gas molecules themselves undergo this same process, as is evidenced by a strong wind from the point to the plate even in perfectly transparent gases. The old familiar experiment of blowing out a candle flame by presenting it to such a charge point is simply another illustration of the same phenomena.

The procedure used to get direct current consisted in transforming the alternating current from an ordinary lighting or power circuit up to some 20,000 or 30,000 volts and then commutating this high potential current into an intermittent direct current by means of a special rotary contact maker by a synchronous motor. This direct current is applied to a system of electrodes in the flue carrying the gases to be treated. While any smooth conducting surface worked well for the plate electrodes, it was difficult to find anything suitable for the point electrodes when working on a commercial scale.

The clue to the solution of this difficulty came from an almost accidental observation. Working one evening in the twilight when the efficiency of the different points could be judged roughly by the pale luminous discharge from them, it was noticed that under the particular conditions employed at the time, this glow only became appreciable when the points had approached the plates almost to within the distance for disruptive discharge, while at the same time a piece of cotton-covered magnet wire which carried the current from the transformer and commutator to the discharge electrodes, although widely separated from any conductor of opposite polarity, showed a beautiful uniform purple glow along its whole length. The explanation lay in the fact that every loose fiber of the cotton insulation, although a relatively poor conductor compared to a metallic point, was still sufficiently conductive from its natural hygroscopic moisture to act as a discharge point for this high potential current and its fineness and sharpness, of course, far exceeded that of the sharpest needle of thinnest metallic wire. Acting on this suggestion it was found that a piece of this cotton-covered wire, when used as a discharge electrode, at ordinary temperatures, proved far more effective in precipitating the sulphuric acid mists, which were then the object of study, than any system of metallic points which it had been possible to construe. Perhaps the greatest advantage thus gained lay in the less accurate spacing demanded between the electrodes of opposite polarity in order to secure a reasonably uniform discharge.

In practice of course a more durable material than cotton was demanded for the hot acid gases to be treated, and this has been found in asbestos or mica, the fine filaments of the one and the scales of the other supplying the discharge points of edges of the excessive fineness required. These materials are twisted up with wires or otherwise fastened to suitable metallic supports to form the discharge electrodes in such wise that the current has to pass only a short distance by surface leakage over them, the slight deposit of moisture or acid fume, naturally settling on them, serving to effect the conduction. If the condition of the gases does not supply such coating sufficiently, a special treatment of the material before being placed in the flue is resorted to.

The Cottrell process has proved a great success commercially and new applications are continually being developed. It has been used to remove sulphuric acid, arsenic, cement dust, zinc oxide, etc. It has not, however, solved the problem of the smelters so far as the farmer is concerned, because it removes liquids and solids only and does not take out the gaseous sulphur dioxide to which the farmer also objects.

The removal of dust from the air is an important matter in some industries. In photographic work, dust particles in the film mean clear spots on the negative and black ones on the positive. In the manufacture of gas mantles, contamination by dust may cause pinholes in the product. Dust and soot in the air may be a very serious matter in the ventilating of electrical generators because 65,000 cubic feet of air may pass through a moderately large generator per minute or about 94,000,000 cubic feet per day. There are a number of

firms which make apparatus for washing and cooling air. All of them remove the dust by spraying drops of water through the air instead of bubbling air through the water, this latter method not being effective. Everybody knows how effectively a rain clears the air and it is this principle which is employed commercially.

When dust is blown about by the wind, it becomes electrified. In South Africa at Bloemfontein at an elevation of 4,500 feet, the normal fine weather charge of the air is positive and seldom exceeds a maximum value of 200 volts per meter. During a dust storm the sign of the charge changes and the value may exceed 500 volts per meter. A so-called dust devil or whirlwind which carries a column of fine sand up two or three hundred feet in the air will affect an instrument two miles away, reversing the charge. This is because the sand particles are charged positively. In England a cloud of dust increases the positive charge in the air instead of decreasing it. This is because the dust in England is usually calcareous and acquires a negative charge. It is also known that red lead acquires a positive charge when blown into the air and sulphur a negative one.

I am indebted to Dr. Reid Hunt for information in regard to another difference between siliceous and calcareous dusts. The flint particles in South Africa are not rounded and the sharp edges of the dust wound the lungs and permit the tuberculosis bacteria to enter, whereas there is not the same danger in the case of calcareous dusts. If dried rhubarb is ground up, the calcium oxalate forms a dust composed of needles and is exceedingly irritating to the lungs.

The blue of the sky is due chiefly, if not entirely, to the blue light scattered by fine drops or fine particles suspended in the air. Tobacco smoke is reddish by transmitted light and bluish by scattered light when the particles are fine enough. If it were not for dust-motes there would be a different and less brilliant twilight. The bending or refraction of light, as the sun's rays pass obliquely from the ether, at sunrise, or at sunset, into the optically denser medium of the air, displaces the apparent position of the sun, elevating it by an amount about equal to its apparent diameter, so that one may still see it and receive its light directly when geometrically it is entirely below the horizon. A little later in the evening and its rays fall upon the upper air too obliquely to be bent down to the earth by refraction, but darkness does not yet ensue, for the rays are scattered by the dust-motes and sent downward from particle to particle, resulting in a soft, shimmering light that almost imperceptibly fades away, and which in higher latitudes, because of the obliqueness there of the sun's path to the horizon, may last for hours.

An observer inside of a bank of fog usually reports that the sky is cloudy and of a gray tint, since this is about the character of the light that penetrates the bank of fog, unless it be a very light fog or haze, or he be near the surface. There is quite a distinction between the tints seen inside a wet fog or cloud and those seen inside a dry fog or haze, such as is always associated with the harmattan on the west coast of Africa. In the latter case the sky has a chalky-white tint and the air is very dry. We attribute the whitish tint not to any moisture, but to the presence of innumerable fragments of microscopic diatoms or siliceous shells. The whitish color of the haze must be attributed to the reflection of light from their surfaces. A similar whte haze occurs in air that is full of grains of pollen, or fine crystals of snow, or almost any other kind of small particles.

At the Krakatoa eruption on August 27, 1883, an immense volume of dust and aqueous vapor was thrown to a great height in the atmosphere above the Straits of Sunda. The antitrades spread this over the Northern Hemisphere, and winds higher up in the tropics carried it westward round the world, forming a layer of minute particles miles above the earth's surface. After sunset, and by virtue of the diffusion of red light by this layer of particles, the whole western sky, even to near the zenith, glared with a lurid red as though lighted up from some great and distant fire. These remarkable sunsets continued, slowly diminishing in brilliance, through the years 1884 and 1885 in temperate latitudes, while their northern limit advanced slowly toward the pole, showing that minute particles of solid matter may float for years in the high upper atmosphere, so long as slowly rising currents buoy them up.

The tails of comets seem to consist almost entirely of colloidal particles. The great comet of 1882 was invisible against the solar disk, a position which corresponds to attempted observation of colloidal particles in the ordinary microscope against a luminous background. It became visible again after passing beyond the sun's disk, a position corresponding to successful observation of the same colloidal particles in the ultramicroscope against a dark background, the eye of the observer being protected from the source of illumination. The streaming of the tail of a comet away from the sun may be due to the ionization of the colloidal particles, and their consequent electrical repulsion, it may be a thermal effect, or it may be due to the pressure of light as was pointed out by Maxwell.

In the very clear air of Egypt the contrast between lights and shadows is very marked because the shadows are illuminated but slightly by diffracted light and are therefore darker than in countries where there is more dust or moisture. If the photographer is to get any detail in the shadows, he must expose a negative about twice as long as one would in northern latitudes under equally favorable conditions. A slight haze increases the brightness of the sky very much.

What we call haze is due entirely to dust, for water vapor does not give rise to haze, though the effect of dust is more marked the greater the amount of water vapor in the air. Aitken has estimated that 12 to 22 billion particles of atmospheric dust in a column of air having a cross-section of one square centimeter are required to produce a complete haze, that is, to make a distant object invisible. This does not mean that we cannot see the distant object, the mountain for instance; it means that we don't see it, which may be a very different thing. When in a trolley car at night in a dimly lighted city, one sees almost nothing outside, because the light coming through the window is masked practically completely by the light reflected from the glass which therefore acts chiefly as a mirror. If the power goes off, as happens occasionally in many places, no light is reflected from the glass, which ceases to be a mirror and becomes a window again. It is then possible to see objects outside quite distinctly. Up to a certain amount of haze our view of the distant object is interfered with chiefly by the light scattered by the haze. If we could eliminate that, we ought to see the mountain distinctly. Most of the light scattered by the haze is polarized and we can therefore eliminate it by the proper use of a Nicol prism.

Many years ago it was shown by Tyndall that the whole effect of light on fog and haze may change in a remarkable way if one varies the ratio between polarized and unpolarized light. When using a Nicol prism a mountain may be seen clearly even though it is almost invisible to the naked eye. The light of the sky is polarized and may be quenched in great part by a Nicol prism while the light from a cloud is not polarized and therefore cannot be extinguished. A cloud may therefore appear to the naked eye dark against a bright sky and may yet appear as a white cloud on a dark ground if the light from the sky is quenched by means of a Nicol prism.

Although this work was done by a distinguished Englishman whose name is known to all scientific men, I have been told that neither the British navy officials nor our own had made any study before the war of these methods of overcoming certain cases of low visibility. The light reflected from the surface of the sea at a slight angle is polarized pretty completely, whereas the light reflected from a vessel is not. During the war people therefore learned to use a Nicol prism or a

form of interferometer to enable them to detect periscopes and camouflaged ships. The aviators were much bothered by haze in taking photographs, but they got round the difficulty in another way. Since most of the light scattered by the haze is of relatively short wave-length, they used a color screen which cut out this light and were enabled to take much better photographs.

If smoke particles are concentrated enough to form a cloud which moves along, they will tend to carry with them the gases inside the cloud because the mingling with the air takes place relatively slowly by diffusion. At the eruption of Mont Pelée when St. Pierre was destroyed, the descending cloud carried down with it large amounts of heated steam. The mean density of the water vapor and the solid particles was greater than that of air and the cloud sank as a whole. In the war the French always mixed some form of smoke with their gas clouds. That had several advantages. It enabled the observers to see what the gunners were doing, it increased the apparent density of the cloud, and it caused the cloud to hold together better than it would have otherwise. It is only fair to say, however, that there are no satisfactory data to show how real these last two advantages are; but one would expect them to be of less importance in gas warfare where the amount of smoke is small than in the case of a volcanic eruption where the total amount of solid matter in the cloud is relatively high. On the other hand a smoke cloud may hold together pretty well for a mile or two, which it could hardly do if the air in the cloud did not move with it to a great extent.

It has been shown that it is possible to adjust a toy balloon so that it will sink in pure air and will rise in air to which smoke has been added. This is another form of the same problem whether a beaker weighs more in case a fly, which is heavier than air, hovers in the beaker without touching it. So long as the fly is there, the fly and the air constitute a medium which is denser than air and consequently the downward thrust is greater when the fly is there than when it is not. If anybody doubts this, let him consider the case where a glass plate is laid over the mouth of the beaker imprisoning the hovering fly. Disturbing factors, such as change of temperature due to the fly, are supposed to be eliminated.

## THE USE AND VALUE OF PHYSICAL AND CHEMICAL CONSTANTS.

By Hugh K. Moore.

Manager of the Research Laboratory, The Brown Company, Berlin, N. H., and Representative of the National Research Council on the Board of Trustees for the American Publication of Critical Tables of Physical and Chemical Contents.

[*At a meeting of the Interallied Chemical Conference held in London, July* 14-17, 1919, *there was formed an International Union of Pure and Applied Chemistry which recommended that in the United States an American Publication Committee should be created charged with the general organization and prosecution of the printing in the United States of critical tables of physical and chemical constants.*

*At the meeting of the International Research Council held in Brussels July* 22, 1919, *the International Union of Pure and Applied Chemistry became the Chemical Section of the International Research Council. The original recommendation in regard to the publication of the tables of physical and chemical constants was confirmed both by the Chemical Section and the Physical Section of the International Research Council. The work of arranging for this publication has been undertaken by the National Research Council in coöperation with the American Chemical Society and the American Physical Society. The present arrangements for this publication have been put into the hands of three trustees, namely, Mr. Hugh K. Moore, Chairman, appointed by the National Research Council; Dr. Edward P. Hyde, appointed by the American Physical Society; and Dr. Julius Stieglitz, appointed by the American Chemical Society. At the request of the Editorial Committee of this Department, Dr. Moore has written the following brief paper on the use and value of chemical and physical constants and the desirability of the American publication of critical tables of them.*—Editors.]

The value to industry of physical and chemical constants and their accessibility in an American publication cannot be overemphasized. They make available in the most compact form and with the least expenditure of time a survey of the present scientific and technical knowledge in any given field in so far as this knowledge can be expressed in figures. Their importance and the importance of their ready accessibility was most conspicuously revealed during the war. Practically the only tables of physical and chemical constants available during the war were in German publications. So insistent was the need in the work of the various scientific bureaus of the Army and Navy and of the Council of National Defense and the National Research Council for these tables that the colleges and universities and industrial laboratories of the country were combed for copies of Landolt and Börnstein's Tabellen (which is the principal German publication). Their use, however, was limited to men who could read German, and in many instances these tables were found to be seriously inaccurate. In addition, not one-third of the constants now called for by the industries are to be found in these Tabellen and not even one-half of the constants asked for by industrial concerns are to be found published anywhere. It is an extraordinary thing that a country, so advanced in science as America fondly believes itself to be, should have been dependent, as far as certain important scientific information goes, on the publications of an enemy country in its own language.

Now that the military struggle between America and Germany has ended, the great industrial war after the war is in full swing, and the accurate determination and accessibility of physical and chemical constants is no less important to American industry on a peace-time basis than it was on the war-time basis. Unless we have scientific literature in the English language so that the information contained therein may be accessible to the great number of Americans who do not understand German, the United States will fall way behind in the industrial competition which is now under way. The early publication, therefore, in America of accurately worked out critical tables of physical and chemical constants is a crying need.

The use of physical and chemical constants enters into the every-day life of the whole nation. For example, the constants of milk vary within certain limits and by means of the variations in these constants it can be readily determined whether the farmer's greatest producer is the cow or the pump. The determination of the value of sugar is made by an instrument known as the polariscope; the change in a beam of light passed through a sugar solution as determined by the polariscope bears a direct relation to the sugar contents of the solution. When we consider the immense quantities of sugar used in the United States it becomes evident that a slight error in the constants of the polariscope may cost the sugar refiners millions of dollars annually. This expense is, of course, finally borne by the consumer of sugar. As far back as the time of Grant's administration the German banks set up laboratories to determine some of the constants of the effect of sugar on polarized light and loaned money for the purchasing of sugar on the basis of these determinations.

It is not generally known that copper forms with carbon monoxide a volatile liquid similar in character to nickel carbonyl. No tables of constants which I know mention this fact, let alone giving the properties of such a compound. Lack of data on this subject has caused the loss of millions of dollars to the copper smelters through flue gases, which loss is passed on to the public.

The lack of figures on the cubical expansion of liquids may cause great expense in addition to being the direct cause of many serious accidents. I give one example. One of the large industrial concerns of the country received orders for

its produce to be shipped in tank cars, and but for the fact that the company had for its manager one of the most brilliant scientists of the country a great loss might have resulted from immediately complying with this order, and this first loss might have been the cause of still other tremendous losses. The manager held up all shipments until he could determine in his own laboratory the coefficient of cubical expansion of the liquid. It was found to be ten times that of water. Had the tank cars been filled to the same volume as one would have filled them had the liquid been water the tank cars would have burst open and the contents run out. Had the liquid caught fire from the sparks from the engine a great conflagration might have resulted. Similarly had these cars been filled with certain liquids which were shipped during the war in large quantities and had such an accident occurred in certain places with a high wind blowing whole communities might have been gassed.

The lack of knowledge of the tensile strength of alloys at various temperatures might cause great damage with serious loss of life. For example, it was proposed by one large industrial concern to use a certain alloy in making tanks to be used at high pressure and high temperature. This alloy had the required tensile strength at ordinary temperature and was remarkable for its acid-resisting quality. But at the temperature under which it was proposed to operate, the tensile strength would have been so reduced that one dislikes to think of the probable fatal results which would have ensued had the experiment been tried. The steam boiler is possible because the tensile strength of steel is greater at the operating temperature than at ordinary temperature. The writer nearly lost his life by not knowing the tensile strength of steel at 100° below zero.

The two disastrous collapses of the Quebec bridge were due to depending on data obtained within too narrow limits. In the construction of high buildings one of the fundamental constants involved is that of the effect of wind pressure and if this is not taken into consideration in the construction of the building there is danger of collapse under a high wind.

The knowledge of the linear expansion of metals is of fundamental importance. For example, the writer knows of a case where a big railroad bridge was constructed at great height above the underlying ground. When the temperature sank to 50° below zero the bridge contracted so that it rested only on two inches of the abutment. It was only by good luck that a serious accident did not occur. The lack of precise knowledge cost the railroad a great deal of money. One may recall that in the building of the famous Eads bridge across the Mississippi River at St. Louis the bridge was finally keyed in place by putting the keystone of the arch in a freezing mixture so as to shrink it to fit while cold in order that as it became heated again to the natural temperature it would expand and lock the structure in place.

Because of the lack of knowledge of the temperatures at which certain solids evaporate immense volumes have been lost in smelting furnaces and cement works. It is well known that if one strokes a cat and then touches a surrounding object one gets a spark from the finger. Also if one scuffs along a floor and touches a radiator the same result occurs. This is called static electricity, and by a knowledge of the constants of static electricity it is now possible to create it in the flue gases of cement kilns and thus recover potash of immense value to agriculturists.

Radiant heat is that kind of heat which passes from one body to another without heating the intervening atmosphere. There is no visible indication of such passage of heat. For instance, the heat received from the sun does not heat the air through which it passes but the heat striking the earth is absorbed and given out in sensible form. The constants in relation to radiant heat are of the greatest importance to our fundamental industries, such as steel, copper smelting, etc. For example, the writer knows of a case where the knowledge of these constants, with the determination of correlated constants turned one mill from a losing proposition into probably the most successful mill in its kind of work in the world.

In the manufacture of the electric light bulb one of the most important facts that must be known is the coefficient of the expansion of glass and of the filaments passing through the glass. If these vary too much the filaments will crack the glass so that the electric light bulb will become useless. The glass and the filaments should have practically the same coefficient of expansion.

In the construction of aircraft the balloons of the lighter-than-air dirigibles have up to the present time been filled with inflammable gases. During the war such aircraft could be set on fire and destroyed by shooting at them with inflammable bullets. America began to make use just at the end of the war of helium gas which is non-combustible and non-reactive. Helium occurs in natural gas but to separate it successfully from the natural gas it is not only necessary to know the specific heat, boiling point, specific gravity and critical temperature of helium but also of all the other gases with which it is mixed. Helium occurs also in the air and can be obtained by liquefaction of the air and fractional distillation.

I once contracted with a refrigerating concern to have it construct such machinery as would produce a temperature of 100° below zero. The gas which this refrigerating concern used was carbonic acid gas, familiarly known in ordinary soda water. The refrigerating plant proved a failure because the manufacturers did not know that carbonic acid gas at low temperature changes in part to a snow-like solid at 56° below zero while the balance remains as a gas exerting a pressure of 20 pounds to the square inch. The partial solidification of the carbonic acid gas made the plant a failure.

In connection with a certain problem it was necessary for me to know the constants of a gas called ethane. In looking up the literature of the subject it was found that neither the specific heat of ethane nor its rate of expansion was known, and the critical temperature of ethane was not correct as given. These all had to be determined before the problem could be solved.

The determination of the flow of rivers in connection with the development of water power is of fundamental importance to the hydraulic and electrical engineers. In some cases a river can be weired while in others, owing to the configuration of the ground, this cannot be done. In a certain case it was impossible to weir a river of very large volume at the point where it was desired to know the flow. Fortunately a railroad bridge crossed the river above the point. The engineer in charge placed on the bridge several tanks of salt brine, the contents of which were allowed to run into the river at a uniform rate of speed. The river passed through a gorge which acted as a very efficient mixer. By analyzing the river for salt below this gorge the volume of the river could be calculated. This analysis could not be done on the spot as it was a long and tedious job but it was thought that, if the electrical resistance due to this small quantity of salt could be determined, volt-meters could be installed by which the volume of the river could be determined. It was found however that the necessary constants were unknown and they had to be determined before the operation could be carried out.

With the increase of the population of the country and a shortage of animal fats it has been found necessary to make up the shortage by the production of such vegetable fats as cotton-seed and peanut oil. By uniting these oils with one of the constituents of water a synthetic lard can be made. This synthetic fat industry now runs into the millions of pounds and millions of dollars annually. The synthesis is effected by means of a catalyst. Consequently the knowledge of the constants of the catalyst is of fundamental importance. The working of a catalyst is not popularly understood. I remember that when I was in school our teacher gave us the following definition of the effect of a catalyst: "A catalyst is something," said the teacher, "which causes a reaction to take place without the catalyst taking any part in the reac-

tion. The following illustration will help you understand this: Suppose there is a boy with a nickel and an Italian with some peanuts. The attraction between the boy and the nickel is greater than that between the Italian and the nickel. Pretty soon another boy comes along with a girl on whom the first boy would like to make an impression. So the first boy now produces the nickel and buys the peanuts for the girl. Thus a new combination has been effected. The nickel is now combined with the Italian instead of with the boy. The girl is the catalyst but she has taken no part in the combination."

A knowledge of the constants of light are of fundamental importance to our industries. The lengths of light waves vary materially. Some of these waves are too long to be seen by the eye and some are too short to be seen but they have effects just the same. Some are of such length that they fundamentally effect the disposition of human beings and animals. For example, in one mill it was found that the labor in one department was very restless and turbulent. It seemed to make no difference from what other department this labor came; the laborers became difficult as soon as they entered this particular department. More than that, these laborers continued to be turbulent citizens even outside of the mill. Something in this department seemed to be having a particularly bad effect upon them. A scientific man who was asked to investigate the matter discovered that there were too many red rays in the light which came into this department of the mill. When this situation was understood he changed the light, eliminating many of the red rays, and the department became as peaceable as any other one in the mill.

The duplication of research work all over the country is costing the manufacturers great sums of money. For example, it was recently found that three separate manufacturers had given the same problem to three different persons at the Massachusetts Institute of Technology. Investigations were conducted by each of these persons without any knowledge of the work of the others. If this is possible in connection with one problem in one institution imagine what may be the duplication of effort and unnecessary expense throughout the country at large. The National Research Council hopes by the compilation and publication of the critical tables of physical and chemical constants to save a large part of this unnecessary repetition of work and outlay of money. With these physical and chemical constants at hand in every industrial laboratory the probable result of certain contemplated procedures can be determined without involving a large expense and experimenting at haphazard with possible failure as a result.

There seems to be nothing just now more important and vital to the industries of the United States and hence to the welfare of the country as a whole than the accessibility of tables of accurately determined physical and chemical constants. It is a very large undertaking and will require large financial support but it is an undertaking which is immensely worth while and which will return many times its cost.

# Research Work of the United States Bureau of Standards

## Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

### CALIBRATION OF BAROGRAPHS USED IN AIRPLANE ALTITUDE MEASUREMENTS.

THE altitudes reached by an airplane are recorded by means of an aneroid barometer, the diaphragm of which is connected to a pen point which in turn traces a line upon a paper chart which is caused to revolve at a definite rate by clockwork. Recording barometers have been used for many years for various kinds of work with satisfactory results, but when employed for recording very high altitudes, such as those now reached by airplanes, certain difficulties arise owing to the character of the instrument.

An aneroid barometer is likewise a thermometer, that is, expansion and contraction of the diaphragm are caused by changes of temperature as well as by changes of atmospheric pressure. Ordinarily such instruments are calibrated to give a correct atmospheric pressure reading at a standard temperature and when required to indicate pressure at any other temperature a correction factor must be employed. The difference between the instrument's reading and the true atmospheric pressure is quite large when extreme temperature variations occur. When an airplane reaches a high altitude—say in the neighborhood of 30,000 feet—the average temperature of the air is approximately 35° below zero centigrade, and, as just now stated, this necessarily results in quite a large inaccuracy in the pressure reading of the instrument.

Recently there has been a great deal of interest shown in various high altitude flights, each one endeavoring to establish a new record for altitude reached by heavier-than-air machines. After the completion of one of these flights, it is hardly safe for the pilot to announce that he has broken the record, if he bases this assertion on the actual reading of his pressure recording instrument. Some correction must necessarily be applied and even if a correction has been previously used for the instrument, it will generally be necessary to re-calibrate it under the peculiar conditions of the special flight in question, particularly if the altitude reached must be known to within a few feet.

The Bureau of Standards has devoted considerable study to the accurate calibration of barographs and has adopted a system which gives a correction more accurate than can be obtained by other means. The system employed by the Bureau consists in placing the recording barometer and thermometer used on the plane in a small chamber so constructed that the pressure within it can be reduced to the lowest point desired, while at the same time the temperature may likewise be reduced. As the temperatures encountered at high altitudes, as just now mentioned, are extremely low, it is necessary to employ special refrigerating machinery using carbon dioxide as the refrigerant to produce the cold within the chamber. The production of the vacuum offers no particular difficulties and can be easily provided for by the use of ordinary apparatus.

The method of carrying out the calibration run is very simple and consists in causing the pens of the two instruments to follow the curves which they traced during the actual flight. Therefore, if, we will say, the pen on the barograph indicates a height of 30,000 feet at a certain point on the chart, it is possible to read by means of a standard barometer exactly what the true pressure is at that instant in the chamber. In this way, the variation of the observed from the true reading at any desired point may be obtained and a curve plotted showing the behavior of the instrument throughout the entire range reached during the flight.

These flight-history tests, as the Bureau calls them, are of great importance, since they furnish the only accurate means of calibrating a barograph and also serve to indicate with considerable accuracy how the instrument will behave under future similar conditions. Quite recently the two 34,000 feet barographs which were used by Major Schroeder in his flight of February 27, have been subjected to a flight-history test

at the Bureau. Quite a difference between the observed and true altitudes have been discovered as a result of this work.

## STUDY OF POWER FACTOR IN POLYPHASE SYSTEMS.

ALTERNATING current distribution systems for light and power are now extremely common, and any improvement in the present methods of properly figuring the cost for such electrical distribution is of great importance. There is a marked difference in the cost to the producing company of supplying loads of different character. Thus, the expense involved in supplying electrical energy to loads in which there is a displacement in phase between current and voltage as is often the case with induction motors, or where there is a lack of balance between the loads of the several phases of a 3-phase system, as when such a system supplies the power for a single-phase electric railway, is considerably greater than the cost of supplying a balanced non-reactive load of the same power. For this reason, it is customary for electric power companies to insert penalty clauses in large power contracts, the object of which is to increase the charge for power taken under the above mentioned adverse conditions. The quality of the load, as regards these conditions, is usually expressed as a numerical factor called the "power factor" which indicates the ratio of the actual power supplied to that which could be supplied at the same cost to the producing company under certain assumed ideal conditions.

Unfortunately, a number of different quantitative definitions of "power factor" are now in use by different engineers and as a result considerable confusion has arisen as to the proper interpretation in electric power contracts. A joint committee has been appointed by the American Institute of Electrical Engineers and the National Electric Light Society to study the question and to suggest a satisfactory definition which could be adopted as standard.

At the invitation of the committee, a detailed mathematical study of the more theoretical side of the question has been made by a member of the Bureau's staff and a paper giving the results of this study has been prepared for presentation at the June convention of the above named society.

This paper points out the type of definition which most logically fits a number of different cases and shows the essentially conflicting character of some of the requirements which should be satisfied by a single definition. It is suggested that the definition of an additional quantity called "balanced factor" will enable these requirements to be met in a much more satisfactory manner.

## COMPARATIVE TESTS OF NORMALLY AND FINELY GROUND CEMENT.

THE data obtained from tests on a normally ground and a finely ground cement of the same brand have been computed and a report issued. These two cements were tested in 1:1½:2, 1:2:4, and 1:3:6 concretes of two consistencies, as well as in a neat mix, and in a 1:3 standard sand mortar. The following results and conclusions were obtained:

1. The strengths of concrete made of the fine cement were regularly and consistently greater than those made with the normal cement so far as the tests have been completed.

2. The percentage increases in strength of the fine cement concretes over the normal cement concretes for different periods were:

| | 2 days | 7 days | 28 days | 3 months | 6 months |
|---|---|---|---|---|---|
| Minimum | 90 | 50 | 30 | 21 | 14 |
| Average | 121 | 66 | 56 | 41 | 42 |

It should be noted that the difference in fineness between the two cements was 12% and to obtain the per cent increase in strength for each per cent increase in fineness, the figures in the above table showing the increase should be divided by 12. The normally ground cement had 86% passing the 200-mesh sieve as compared with 98% for the finely ground material.

3. These percentage increases were highest at the earliest ages and the leanest mixes.

4. The strength increases in lb. per sq. in. of fine over normal cement concrete were greater in the mixes containing the greater proportions of cement.

5. If the two cements had been used on a job, the following approximate mix proportions could have been used to give the same strength at 28 days, if consistencies and aggregates were the same:

| Using Normal Cement | Using Fine Cement | Approximate Saving in Bags of Cement per Cubic Yard |
|---|---|---|
| 1:3½ | 1:5 | 2.1 |
| 1:4½ | 1:6 | 1.5 |
| 1:6 | 1:8 | 1.2 |

(Proportions were one part of cement to sum of volumes of sand and gravel measured separately.)

6. When used in 1:3 mortar, the fine cement produced a more marked percentage increase than when used in the concretes. The percentage increases in the neat mixture, however, were of the same order as in the concretes. Thus, in the cases of cements tested, the results of the work on neat cements gave a better indication of their value in concrete than tests in a 1:3 Ottawa sand mortar.

7. In most cases, the fine cement required no more water than the normal cement to produce a given consistency, when the aggregates and mix were the same.

8. It was found that when the special cement was tested for fineness on the 200-mesh sieve, the lumps of very fine material were not broken up under the sieving action and would not pass through the meshes, but when this cement was tested by the air analyzer these lumps were broken up and the results thus secured gave a true indication of the fineness of the cement. It is, therefore, recommended that the air analyzer be used in determining the fineness of very fine cement whenever possible, but that if this cannot be done care should be taken to prevent this balling on the 200-mesh sieve if the determination is made in the usual manner.

## REFRACTORY CRUCIBLES.

DURING the past month, the making of crucibles from highly refractory oxides and minerals has been investigated. It has been found possible to make such crucibles without the use of clay or binder which would tend to reduce the refractoriness of the finished product. One method is to make the crucible with the use of water by tapping the plastic mass inside of a fire clay mold lined with plaster-of-paris. When the mold and crucible are fired to a red heat, the plaster-of-paris disintegrates and permits the crucible, which is then fairly strong, to be removed from the mold. The crucible is then fired to a high temperature in order to give it the necessary density and strength. The other method is to mix linseed oil with a refractory oxide and then to shape the crucible inside a detachable metal shell; the crucible is then baked in the shell in a core oven, a similar process to that employed in the baking of cores for castings. After the baking, the shell is removed and the crucible fired to a high temperature which results in a burning out of the temporary carbonaceous binder and sintering of the refractory oxides, thus forming a dense, strong, and highly refractory crucible. Working in this way, crucibles have been produced from titanium dioxide, zirconium dioxide, and carborundum fire sand. The investigation is being continued.

## INVESTIGATION OF COMPOSITION AND PREPARATION OF A SUCROSE-INVERT SUGAR SYRUP.

A NEW investigation on the standardization, composition, and preparation of a sucrose-invert sugar syrup of maximum concentration has been brought to completion and the manuscript is in course of preparation.

One of the large branches of the sugar industry is the manufacture of syrups for direct consumption. If the syrup consists only of sucrose, the saturated solution may contain only 68.7 per cent of the sugar. Such a solution is too thin for a desirable product and is susceptible to fermentation. If concentrated to a denser consistency, it becomes supersaturated and deposits sugar crystals. If, however, the sucrose is partially inverted, the density may be considerably increased, but if the inversion is carried too far, the relatively low solubility of dextrose limits the density to which the syrup may be concentrated.

A study was made of the mutual solubilities of the three constituent sugars, namely, sucrose, dextrose, and levulose in the presence of each other. Equal proportions of dextrose and levulose in solution constitute "invert sugar" which is formed by the inversion of sucrose. The solubility of sucrose in varying proportions of invert sugar was determined to very high concentrations of the latter. Similarly, the solubility of sucrose in the presence of dextrose, and of dextrose in the presence of sucrose, and finally of dextrose in the presence of levulose were measured. With the exception of some measurements on the solubility of sucrose in the presence of invert sugar, no determinations of these solubilities have previously been recorded.

The results of this investigation have shown the maximum concentration which invert sugar may have without depositing crystals of dextrose, and similarly the maximum concentration which a mixture of sucrose and invert sugar may have without depositing either sucrose or dextrose. The syrup which contains 33.7 per cent of sucrose and 44.8 per cent of invert sugar, or a content with respect to total sugar of 78.5 per cent, has this maximum concentration. In general, it is practicable to increase this concentration even to a slight supersaturation without danger. Such a solution is sufficiently dense for a good syrup and resists the growth of micro-organisms.

A number of methods of inverting sugar have been devised. The Bureau adds the suggestion that the partial inversion can be accomplished by the aid of an extremely dilute hydrochloric acid and subsequent neutralization with sodium carbonate. The net result is the addition of a minute quantity of common salt. Data are provided for controlling the method.

# Notes on Science in America

## Abstracts of Current Literature

### Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

#### CALIFORNIA EARTHQUAKES DURING 1919

IN the Bulletin of the Seismological Society of America, for March, 1920, is an article by Mr. Andrew H. Palmer, Meteorologist of the U. S. Weather Bureau, on California Earthquakes during 1919. The substance of Mr. Palmer's article is as follows:

Since July 1, 1914, the U. S. Weather Bureau has kept a record of all earthquakes which have occurred in the United States. Seismographs are now maintained by the Bureau at Washington, D. C., Chicago, Ill., and Northfield, Vt. In the collection of earthquake data the Bureau also has the coöperation of every other seismographic station in North America. Records of earthquakes strong enough to be felt by persons are also gathered. It is believed that few, if any, earthquakes of sensible intensity occur without being reported by one or more of the 4,500 correspondents who are distributed throughout the United States. The seismological work of the Bureau is in charge of Professor William J. Humphreys, and the data are published in the *Monthly Weather Review*, an official government publication.

In California, about 350 correspondents have volunteered to coöperate in the collection of reports of earthquakes strong enough to be felt by persons.

A total of 101 separate and distinct earthquakes strong enough to be felt by persons occurred in California during the year 1919. The monthly distribution of these shocks was as follows:

In Jan., 5; Feb., 21; Mar., 9; Apr., 2; May, 5; June, 4; July, 4; Aug., 6; Sept., 19; Oct., 18; Nov., 2; and in Dec., 6.

The disturbances were most frequent along the coast and in the Imperial Valley. They were least frequent in the Sacramento-San Joaquin Valley and in the Sierra Nevada Mountains. Southern California experienced far more shocks than northern California. Calexico, in the Imperial Valley, on the Mexican border, had forty-two earthquakes during the year. On the other hand, San Jacinto, where the most severe earthquake in recent years in California occurred on April 21, 1918, did not report a single seismic disturbance during 1919. Of the larger California cities, the number of earthquakes experienced during 1919 was as follows: San Francisco, 4; Los Angeles, 2; San Diego, 2; Fresno, 1; Santa Barbara, 3; Oakland, 2; Berkeley, 3; San Jose, 1; Eureka, 10; Bakersfield, 2; Redlands, 1; Riverside, 1; and San Bernardino, 1. None were felt at Sacramento or Stockton. At Lone Pine, a recognized epicenter, five earthquakes occurred. At Spreckels, another region recently active, but one was felt.

But sixteen of the 1919 earthquakes were sufficiently wide-spread to be felt at two or more adjacent stations. The other eighty-five were so light and local that they were felt at one station only.

The strongest and most widely felt earthquake of 1919 in California occurred on the morning of February 16th. It was felt throughout the region extending from Fresno to Los Angeles, and was most intense in the Kern County oil fields. This shock caused the only material damage done by a California earthquake during the year. A pipe leading to a 55,000 barrel oil tank in Kern County was broken, and the petroleum escaped. About 52,000 barrels of oil was lost. The oil was thrown so high into the air that it splashed over half the top of an adjoining tank, thirty feet distant. A stone building at Taft was cracked by the same tremor, and the pumps in an oil pumping station near McKittrick were stopped.

One cannot consider the California earthquake records of the past five years without discovering a constancy from year to year in the kind, number, intensity, and distribution of shocks. The inevitable conclusion appears to be that the disturbances are more or less normal to the present state of the earth's crust. In fact, these slight but constantly recurring tremors may well be regarded as a safety valve in efficient operation.

#### EFFECTS OF ANAESTHETICS ON PLANTS.

AN account of the effects of anaesthetics on plant life and of the discoveries as to the nature of plant processes which such effects reveal, as found by Sir Jagadis Chandra Bose, is given in *American Forestry* for April.

Sir Jagadis discovered that it was possible to transplant trees without injuring them if the operation were performed while they were subject to the effects of an anaesthetic. A tree so treated sheds its leaves after transplanting in the summer instead of in the autumn, but it very soon recovers itself and becomes normal.

The most intense activity of life was often imperceptible, and it was only by making the unseen visible that the mystery of growth and movements of life would become revealed. Sir Jagadis showed that by the crescograph the highest powers of the microscope were magnified 10,000 times. No experimental conditions for exhibition of growth could have been more difficult than in the depth of English winter, when plants were in their period of hibernation. In spite of this they were made to shake off their torpor, and the rate of growth was exhibited by the indicating spot of light rushing across a ten-foot scale in the course of twelve seconds, the actual rate being about a hundred-thousandth part of an inch per second. With the crescograph to guide him, the life-activity of the plant became subservient to the will of the experimenter.

A depressing chemical agent was applied and the march of life was slowed down; a timely application of a suitable stimulant revived the dying plant and exalted the growth-activity to many times the normal rate. The possibility of modifying the rate of growth was a matter of great practical importance, for the world's supply of food depends on the growth of plants. The rule-of-thumb method hitherto employed in the application of a few chemical stimulants and of electricity was not found uniformly successful. Researches by means of the crescograph showed that a very important factor was the dose of application, any excess above the critical point bringing about a result diametrically opposite to what was expected. Thus while a particular intensity of electrical current accelerated growth an excess of current retarded it. The same was true of chemical stimulants.

## THE PLANETESIMAL HYPOTHESIS IN RELATION TO THE EARTH.

PROFESSOR REGINALD A. DALY of Harvard University is the author of an article in the SCIENTIFIC MONTHLY for May, on The Planetesimal Hypothesis in Relation to the Earth. Professor Daly quotes the following summary of this hypothesis as given by Barrell:

"The volume of a star (the sun) represents a balance between expansional and condensational forces acting on a vast body of gaseous nature. On the approach (of another star) their mutual gravitation would produce tidal forces diminishing their self gravitative power along the line between the centers and give the expansive forces opportunity to rise to explosive violence along that line. This tidal force is actually greatest at the centers and would lead to a very deep-seated disruption. The gas bolts shot out would, owing to viscous resistances, be pulsatory, and separated nuclei would therefore be expelled. These nuclei and the associated dispersed matter would, on the nearer side, be dragged sideways by the passing star. On the reverse side the symmetrical tidal protrusions would be left behind, the sun being dragged more than they. The result would be a spiral nebula, a form which would meet the dynamic demands of the existing solar system. . . .

"The building up of the planets is believed to have followed three stages: first, the direct condensation of the nuclear knots of the spiral into liquid or solid cores; second, the less direct collection of the outer, or orbital and satellitesimal matter; third, the still slower gathering up of the planetesimal material scattered over the zone between adjacent planets. This third factor in Chamberlain's view is regarded as very important and he believes this diffused matter contributed much of the earth substance very slowly and in a dust-like form. This is one of the critical points in the details of the theory, unessential to the larger framework, but upon which turns much of the development of the following argument. In earth-growth the denser planetesimal dust, Chamberlain argues, tended to be somewhat segregated into the primitive ocean basins and served to maintain in them, as the earth was built outward, a greater density than in the elevated zones between. . . .

"The earth is conceived as beginning to hold an ocean by the time it contained 30 or 40 per cent of its present mass. . . .

"The particles of radioactive matter (in the earth) would tend toward local heating and fusion. Thus they would be progressively concentrated into the outer shell of the earth by the rising of igneous matter. Pulsatory stresses from body tides and from shrinkage are regarded as the chief agents leading fused matter outward and serving to maintain the earth's body in solid form."

In comment on this hypothesis, Professor Daly says that it represents one of the grandest achievements of modern science. The distribution of masses and momenta the directions of revolution and rotation, and the constitution of each member of the system, so far as ascertained, are explained with such a degree of probability that astronomers are becoming more and more impressed by the planetesimal hypothesis.

Professor Daly then goes on to discuss some of the implications and limitations of the hypothesis, with special reference to Professor T. C. Chamberlain's recent work on "The Origin of the Earth." First he finds that neither the mass nor the temperature nor the dynamics of the original earth-knot or nucleus are deducible from the root premise of expulsion from the sun.

Chamberlain appreciates this fact and concludes that the temperature of the innermost core of the earth must remain an open question. He also states that the mass of the planetary nucleus may have been so large and the ingathering of the planetesimals may have been so rapid, by hypothesis, that a molten or even a gaseous condition could have arisen. In the case of the larger planets such a primitive state is quite within the limits of the probabilities. The case of the earth is debatable.

Yet, notwithstanding his own unescapable conclusion, Chamberlain believes that the earth, with a mass only about one-third of its present value, was already well crusted, if not essentially crystalline to the core. He assumes that a water ocean could then lie on the earth's surface, and that the heat of self-compression, chemical heat, and heat generated in radio-activity have never sufficed, since this embryonic stage, to melt the surface shell of the globe. With these assumptions, which are not implicit in his main astronomic hypothesis, Chamberlain proceeds to picture the juvenile shaping of the earth.

Professor Daly finds that while the general hypothesis assumes similar origins for all the planets, it does not stand the test of criticism. For even more surely than the Laplacian hypothesis, the planetesimal hypothesis demands that all planets shall have a large proportion of elements with high atomic weights. If so, the outer planets must have high temperatures, as so long held by astronomers.

If this be the case half of the planets must still be so hot as to be gaseous, although by hypothesis they are nearly as old as the earth and are probably composed of material which is much like the average material of the earth. At this late day the four outer planets must be losing heat many times faster than the earth is losing heat through a solid crust and still they are incomparably hotter than our globe. According to the planetesimal hypothesis, they are so hot because of their size. If the common mechanism produced in four full-grown planets temperatures sufficient for nearly complete volatilization of highly refractory substances, temperatures persisting after more than one hundred million years, is it reasonable to assume that the mechanism failed to produce the much lower temperature needed for surface liquefaction of a fifth planet a hundred millions years ago? Do not these homologies suggest yet more a gaseous condition for the earth after it had attained its present mass?

In summary, Professor Daly finds that the planetesimal hypothesis leaves indeterminate most of the essential factors affecting the earth's successive temperatures, namely, the ratio of nuclear mass to planetary mass, the initial temperature of the earth-knot, the rate of accretion, the heating fac-

tors, the cooling factors, and the absolute time involved. Hence the present condition of the other planets ought to have special attention by any one who attempts to trace the earth's history down into "Archean" time.

Discussing the early crust of the earth as a "blanket on the earth surface" Professor Daly concludes that the general hypothesis does not necessitate belief in crustification of the earth until it had attained its present mass.

As regards the earth's rigidity the author finds that the combination of the facts known about the solar system as interpreted by the planetesimal hypothesis furnishes a cumulative argument in favor of assuming a molten or even gaseous state for the earth's surface shell after our globe had grown to full size. Chamberlain's selection of a strongly contrasted possibility of his cosmogonic scheme is due in part to overemphasis on some elements of the scheme, especially those contrasting with essential features of the Laplacian cosmogony.

The author also discusses the relation of the hypothesis to Igneous Action, to the Generation and Transfer of Heat, to Subsidence and to Eruption, and to Eruptive Sequence. His conclusion is that while many facts of igneous geology are inexplicable on a cosmogonic theory which postulates a general solid (crystalline) condition for the earth during most of its growth this is, however, not a necessary feature of the planetesimal hypothesis, which, apparently sound itself, points rather to the probability of a fluid state for the earth both before and for some time after accretion was completed. Making the more probable deduction from Chamberlain's cosmogenic scheme—an earth once largely fluid from the surface downwards—the facts of geology are better understood. Among the leading facts are: (1) the density stratification of our planet, induced by early gravitative differentiation in gas or liquid; (2) the dominance of gneiss and granite in the early pre-Cambrian complexes, which represent the rearranged material of the earth's primitive crust (a surface differentiate of low density); (3) the dominance of basalt in fissure eruptions, with other facts indicating the existence of a world-circling basaltic *couche* below the crust (the upper layer of Suess's "Sima"); (4) the genetic connection between geosynclinal down-warping and mountain-building with igneous eruption; (5) the number, lengths and wide distribution of dikes of uniform diabasic composition; (6) the subsidence of the floors beneath major volcanic masses and of the floors beneath the greater baccoliths; (7) certain stress-strain relations of the earth, since the high rigidity of the earth, for example, may be partly due merely to primitive differentiation according to gravity.

The author concludes that as applied to the earth's later history, the planetesimal-nebula hypothesis thus appears to overlap the gas-nebula hypothesis. In each case a fluid state for the earth is fairly deducible from the astronomic premises. Since the objective facts of astronomy and of geology, especially igneous geology, points in the same direction, the assumption of primitive fluidity seems to be the best working hypothesis on which geology can be based. Meantime, our profound ignorance of the behavior of silicate and metallic melts at very high temperatures and pressures should prevent fixed opinion concerning the cause of the earth's high rigidity. Similarly, the mystery attaching to the original potentialization of energy in the radioactivity elements makes uncertain the true relation of radioactiviey to the earth's internal heat.

## RESEARCH IN THE PSYCHOLOGY OF AVIATION

CAPTAIN HARRY M. JOHNSON of the Sanitary Corps, U. S. A., in charge of the department of psychology of the Air Service Medical Research Laboratory at Mitchel Field, L. I., since January, 1919, presents in *Science* for May 7, a résumé of research in the Psychology of Aviation. The more salient points of Capt. Johnson's report are as follows:

During the year the department prosecuted research along two distinct and independent lines: (1) an effort to gain a somewhat more intimate acquaintance with the effects of low oxygen on the integrity of response; and (2) an effort to develop more sensitive tests for the detection of (a) general aptitude for aviation work, and (b) of its deterioration in the earlier stages of staleness.

An extensive and detailed statistical study of the records of over 6,000 classification-tests for resistance to deprivation of oxygen has been made. The results indicate the extent to which the subject's performance may be affected by atmospheric pressure, temperature and humidity; by the absolute quantity of oxygen supplied the subject in the air to be rebreathed; by the duration of the test; by the time of day at which the test is taken; by the judgmental eccentricities of the psychological and clinical observers, and by a lowered morale, such as that which immediately followed the Armistice. With these data available it is now possible, by controlling or correcting for the influence of these variables, to approximate much more closely to uniformity and constancy of the standards of classification than has been possible hitherto.

An investigation was made on the influence of diminished pairment and behavior by the use of an objective record of the speed and accuracy which the subject can maintain in carrying on work of uniform difficulty as the supply of oxygen is being diminished. Some interesting records were obtained, which however, do not give the quantitative measure of impairment which the appearance of the graphs suggests. One reason for this fact is that many subjects tend to compensate for impairment of response by an increase of "voluntary" effort. Tests on the fluctuations of visual acuity over extended periods of observation were made, and some results thus obtained that were not fully expected; e.g., (1) it appeared that fixation and accommodation upon a stationary object can be maintained until the last stages of asphyxiation have been reached; and (2) that in the last stages of asphyxiation, visual impressions may become intermittent and the entire field become darkened, without the outlines of objects appearing blurred, and without diplopia developing under the conditions of this particular test.

An investigation was made on the influence of diminished air-pressure, simulating an altitude of 20,000 feet, on the time required for selective reaction to a number of combinations of signals visually perceived. The data as obtained indicate that the time required for selective response is greatly lengthened and its variability increased, by the abnormal conditions of the experiment, until the subject by continued practice has rendered his responses almost purely mechanical.

The results of a number of tests of aviational ability show the tests taken as a group have some diagnostic value and that certain of the individual tests if further refined may have considerable practical value. An important fact exhibited by the data is that flying grades do not adequately differentiate aviational ability.

The results of a number of tests of aviational ability show that the scores of the subjects in two of the tests are highly correlated with the estimate of aviational ability as made by the training department, the coefficients in both cases being approximately 0.73. It is safe to say that if six to eight tests as satisfactory as these were developed, they would afford a better basis of prediction of flying-school performance than is afforded by the cadets' records in civil life, or by their performance in ground school, etc. It is planned to continue the effort to develop such tests.

Preliminary work in the department suggested that two forms of test, if sufficiently refined, might prove to be quite valuable in diagnosis of aviational ability and in exhibiting its impairment. These tests are (1) of the ability to control the coördinated activity of certain systems of voluntary muscles; and (2) of the *relative* time required for selective reaction to one of three signals presented successively and in irregular sequence (a) under a standard condition of observation and (b) under a condition of observation so difficult as to be trying.

# Progress in the Field of Applied Chemistry

## Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

### INDUSTRIAL FELLOWSHIPS

ATTENTION is called to the 7th Annual Report on the Industrial Fellowships of the Mellon Institute issued for the fiscal year ending February 29, 1920.

It will be recalled that the industrial fellowship system was formulated by Robert Kennedy Duncan in 1906 and was placed in experimental operation at the University of Kansas in January, 1907. It was inaugurated at the University of Pittsburgh in September, 1911, and in March, 1913, Messrs. Mellon placed it upon a permanent basis. The experiment has interested scientists and industrialists everywhere, and the Institute has frequently been studied by our foreign friends.

In addition to the foundation sums provided by the donors of the fellowships, the Institute cares for the overhead expenses, in which the salaries of the permanent staff and office force, the maintenance of buildings and the purchase of books and apparatus is included. In the fiscal year ending March, 1912, there were eleven fellowships with 24 fellows, the foundation sum being $39,700. This has steadily increased without decreasing at any time until for the fiscal year ending March, 1920, the number of fellowships was 47, the fellows 83, and the foundation sum $293,680. As the report points out, there has been several million dollars spent in addition by the industries in developing, upon a commercial scale, the processes resulting from the research work at the Institute. The problems which have been under investigation are quite diverse in character. The work demonstrates the possibility of conducting fundamental research on a coöperative basis, for on March 1st, 1920, a fourth of the fellowships were of the multiple type supported by Associations. These are Leather Belting, supported by an association with 37 company members; Fiber, the association having 20 members; Magnesia, four members; Insecticides, 8 members; metal ware, 11 members; refractories, 94 members, and laundry, 1,850 members. Some of these fellowships are of long standing; two of them having been in operation since the founding of the Institute, so that the possibilities seem to have been pretty well established.

Much of the work has resulted in patentable processes, the number of patents issued during the year being 7 in 1914, and 37 in 1919.

The Institute distributes a limited number of its publications, and in the report in question a list of the industrial fellowships in operation is given in detail.

### PROBLEMS IN WOOL MANUFACTURE

SEVEN problems in wool manufacture which might be undertaken to advantage by the Bureau of Standards were discussed in a conference reported in Bulletin No. 2, vol. L, page 148, of the National Association of Wool Manufacturers. These problems are first, the standardization of dyestuffs. Second, the comparison of the two processes of cleaning wool, namely, the usual alkaline process and the naphtha. The advantages and disadvantages of the processes themselves and the effect on the working properties of the wool fiber should be determined. Third, the two processes of carbonizing wool or woolen fabrics should likewise be studied along the same lines. These processes are sulphuric acid, and the application of aluminum chloride. Fourth, the relative desirability of fabrics made from carded yarns and from worsted yarns should be determined from the standpoint of warmth and wearing qualities. Fifth, it is desired to learn the effect both upon warmth and the wearing qualities of fabrics with the introduction into the blend with virgin wool, of shoddy of different grades, and also of cotton. Sixth, the limits of advisable use of petroleum neutral oils in combination with other oils for the purpose of lubricating the fiber before carding, taking into consideration as well the important point of thoroughly eliminating this oil by a scouring process from the woven fabric. In carded woolen mills, various oils and combinations are used, but heretofore olive oil and peanut oil have been used in worsted mills and the inquiry applies to both classes of manufacture. Seventh, the determination of the amount of grease desirable to leave in wool when scoured.

It is understood that plans are being formulated for carrying on this work at the Bureau of Standards, which desires whenever possible to engaged upon scientific research calculated to be of advantage to the industries.

### JELLY

WE are coming to learn that jelly is a scientific production, although many maufacturers may never have so considered it. Experiments have been conducted in an endeavor to learn in what proportions the necessary raw materials should be used to produce a reliable commercial product of constant quality, and the results of this investigation are reported by E. H. Campbell in the June number, page 558, of the *Journal of Industrial and Engineering Chemistry*. Three ingredients must be present in proper proportions for best results. These are acid, pectin, and sugar. It has been found that an excess of pectin decreases the amount of jelly, although it produces a firm but tough product. In commercial jellies pectin should not exceed 1.25 per cent. Home-made jellies have from .75 to 1 per cent. When calculated as sulphuric acid, the minimum acidity in a jelly of good quality is 0.27 per cent and the maximum 0.5 per cent. A good acidity is 0.3 per cent. An insufficient amount of sugar produces a tough jelly and an excess amount one that is soft.

To determine these different factors a considerable number of experiments have been conducted. One constituent was varied at a time and upon the data obtained the conclusions given above were reached. Thus a series of tests was run with amounts of sugar per gallon of apple juice in which the pectin content was uniformly 1.25 per cent and the acidity 0.43 per cent with from 2 to 11 pounds of sugar for each gallon of juice, varying the amount by one pound in each successful test. The lot containing 5 pounds of sugar per gallon of juice was chosen as the best in texture for commercial use, though that with 6 pounds gave the most desirable flavor. The jelly improved in delicate flavor approaching the characteristics of home-made jelly as the sugar was increased up to the point where it became too sweet and altogether too delicate for commercial use.

Another interesting development has been the relationship established between the brix hydrometer reading of the fruit juice made from apple pomace and the amount of sugar to be added per gallon of juice. On the brix hydrometer the scale indicates the percentage of sugar in the solution under test, assuming all dissolved solids to be sugar. It has been found that if one pound of sugar is used for each gallon for every degree brix a fine, clear jelly, firm enough to stand under nearly any climatic condition, will result. A more delicate jelly is made by using 1.25 pounds of sugar for each degree brix; the amount of sugar used increases the amount of jelly as the sugar is increased.

The author gives a method for determining pectin present; one quick, rough test being as follows: If 10 cc. of filtered juice are allowed to drop from a pipette into 180cc. of alcohol

amounts of pectin over one per cent in the juice will cause a cohesive, gummy mass to gather, but if the amount is less than one per cent the precipitate will not gather in a mass but will remain flocculent. One soon learns to observe this precipitation, which is usually accurate enough to serve as a check.

By thus controlling the manufacture of jelly from the pectin standpoint, and the author gives a table indicating the sugar to be used per gallon of apple juice on a pectin base, it is possible to obtain a more uniform product than is customary, together with increased production and an improvement in production which again testifies to the desirability of working upon an accurate scientific basis.

## THE GAS MANTLE.

THE United States Tariff Commission in its Tariff Information, Series No. 14, presents an interesting account of the incandescent gas mantle industry, its raw materials and by-products. The pamphlet is issued as an aid to the study of the tariff and understanding of its effect on domestic industries. Articles considered are monazite sand, thorite, thoramite, cerite, thorium nitrate, cerium nitrate, incandescent gas mantles, cerium pyrophoric alloy, and mesothorium.

The incandescent gas mantle not only gives the cheapest illumination wherever natural or manufactured gas is available, but has actually saved the gas lighting industry. Its use enables a very satisfactory light to be obtained with a wide variety of gas, since illumination depends upon the temperature to which the oxides forming the mantle are heated. It is estimated that of the 300,000 mantles used in the world, 80,000,000 are required by the United States where the domestic industry is well developed. To produce these mantles about 3,500 tons of monazite sand containing from 4 to 12 per cent of thoria and 30 per cent of ceria are required. The best proportions of thorium and cerium for use in mantles to give not only intense light, but light of the most satisfactory color are 98 to 99 per cent of the former and 1 to 2 per cent of the latter. This leaves a quantity of cerium much in excess of the demand for mantle production and in addition monazite sand contains about 30 per cent of other rare earths.

Utilization of this material has been an interesting research problem as has the production of the radio-active substance mesothorium, a by-product in the manufacture of thorium nitrate. It is expected that since mesothorium has the same therapeutic application as radium one year after its isolation that it will play an important part in supplementing our restricted radium supply.

A considerable part of the surplus cerium is used in producing pyrophoric alloy, an alloy with iron which serves in gas and cigar lighters, where a spark is produced by friction with this alloy. In its production, the iron is alloyed with about 30 per cent of cerium or the mixed rare earth metals which are a by-product in the treatment of monazite sand.

The consumption of pyrophoric alloy in the United States is about 20 tons per year. A small quantity was used in star shells during the war, tracer bullets in which the friction of the air during the flght caused the alloy to burst into flame, and of course in automatic lighters for use where matches were forbidden.

While there are approximately 30 manufacturers of gas mantles in the United States, only one manufacturer produced thorium and cerium nitrates from monazite sand in large quantities prior to the war. A second manufactured on a small scale and the others imported their thorium nitrate, the total imports about equaling the American production. The English and French mantle makers have also been in the habit of imporfing their raw material, so that with the advent of the war the American companies by expanding their production were able to supply both domestic and foreign demands.

The bulletin is supplied with numerous tables of interesting statistics and possible outlines of methods of manufacture.

## SUBSTITUTES FOR PLATINUM

IN the May issue of the *Journal of Industrial and Engineering Chemistry*, page 500, a note is reported on the successful use of substitutes for platinum wire in bead and flame tests. The results quoted are from the experience of Mr. C. Kiplinger of Mount Union College. As he points out, one very important source of waste in platinum arises from its use in the qualitative laboratory. A platinum wire sealed into a glass rod is used in flame and bead tests where it alloys with many of the metals with which it comes into contact, and rapidly disappears subsequently. To avoid this waste, it has been found feasible to use the graphite from a lead pencil in place of wire for bead tests, a small length of this graphite is held in the flame of a Bunsen burner until the end is hot. It is then dipped in borax and returned to the flame, holding it at such an angle that a hanging drop on the end of the graphite is formed of the borax glass. This drop constitutes the bead and the tests are made as usual. Each 5 to 6 cm. length of the graphite easily serves for at least two tests, one at each end, and occasionally it can be scraped clean enough to permit several tests with one piece. A bead of the right size will adhere firmly to the graphite, yet the cold bead is easily removed with a knife. The reducing action of the carbon does not seem to make a difference.

The writer further suggests the use of an iron nail not less than 3 mm. in diameter. The large surface offered by the head of the nail seems well adapted to the purpose and by burning it free from sodium satisfactory results are obtained, since the spectra of the iron salts do not interfere.

Still another suggestion is an improvement upon the method of Ehringhaus, where a glass tube 15 cm. long and 6 mm. internal diameter is bent at an angle of 45 degrees, 2cm. from one end. In this end the opening is reduced to 3 mm. in diameter by holding it in the gas flame. A wick of filter paper with 3 cm. projecting is fitted in the reduced opening and the longer arm filled with the solution to be tested, or with dilute hydrochloric acid if a powder is to be tested on the paper. A flame of sufficient duration for observation can thus be obtained. By supporting a burner horizontally on a stand and bringing the upper edge of the paper wick barely within the bottom portion of the flame, the warm solution is vaporized and covers the flame with a minimum consumption of papers and the elimination of the carbon flame, which otherwise intereferes with direct vision work.

## CATTLE FOOD FROM SEAWEED.

IN the weekly bulletin of the Department of Trade and Commerce, Ottawa, Canada, there appears a report taken from a London Chamber of Commerce journal describing a process which has been tried in Denmark of producing cattle food from seaweed. From the analysis it would appear that the food is nourishing and would appeal to cattle. The plant must first be washed to free it from excess salt, etc., after which it is steamed under high pressure, which causes the cells to disrupt. The mass is then formed into cakes under high pressure, dried in a vacuum and ground to powder. The juice of the mass collected during the pressing operation is concentrated in vacuum, the salts crystallized out and separated in a centrifuge. The juice is then mixed with the coarse powder and the mixture pressed into suitable sized cakes.

The finished cake shows the following approximate analysis: Water, 5 per cent; protein, 13.12; fat, 1.07; digestible carbohydrate, 66.76; cellulose, 9 per cent, and mineral salts, 5.03 per cent.

## PEARL BARLEY.

THE Plant Chemical Laboratory, Bureau of Chemistry, has made a study of the methods of manufacture of pearl barley and the chemical composition of the various products of the pearling operations. It is interesting to note that the offal from the sixth pearling has essentially the same composition as the pot barley resulting from the second pearling opera-

tion. This is important since this material should be useful as barley flour. It is estimated that about 5,000,000 bushels of barley are now made into pearly barley and on this basis 52,000 tons of barley material containing over 6,700 tons of protein, 1,000 tons of fat and 1,100 tons of mineral ingredients are now removed in the steps between pot barley and pearl barley. This waste now goes into animal foods.

Both pot and pearl barley result from the gradual grinding off of the outer layers of the barley grain. This is called pearling and the pot barley results from two or three such operations, pearl barley results from 5 to 6 such treatments, the abrasion being carried on until a white, pearl-like product is obtained. Some times sulphur dioxide is used to whiten the final product and not infrequently talc or similar material is added to brighten and improve the pearl-like appearance. This is occasionally referred to as mineral facing.

The pearling machine generally contains a vertical abrasive stone enclosed in a metal sieve and a dust proof housing. The sieve revolves two-tenths as fast as the stone and in the opposite direction. The barley is fed in and discharged automatically, the grinding or abrasion continuing for about two minutes, which after cooling is ready for the next treatment. A reel separates the offal or husks from the barley.

In making pot barley a loss of 22 per cent of barley material is sustained. In continuing the operation to the pearl barley stage, 65 per cent of the barley material is lost. The report of this work gives an analysis of each of the coatings removed in the different operations and emphasizes the need of finding some way properly to use the materials so removed.

## BRASS.

THE Bridgeport Brass Company has issued an attractive brochure entitled Brass, in which, under the heading, "Seven Centuries of Brass Making," a brief history of the ancient art of brass making and its early and even recent method of production is contrasted with that of the electric furnace process. The historic account which even notes labor conditions in the Middle Ages, and, as is the case with the entire publication is well illustrated, is particularly interesting. Studies of our oldest ruins indicate that in the earliest periods of man's development he knew something of the metallurgy of copper, tin and iron, it being believed that copper was probably the first to be used. During the Bronze Age it is believed that charcoal and ore were burned in shallow pits in the ground and after cooling, the melted copper was recovered in the form of a rough disk. Seemingly, the first copper came from Sinai and then later from Cypress. Some believe that the earlier bronzes resulted from the direct smelting of stanniferous copper ores, although others think that the tin was obtained as such from Spain and Great Britain and alloyed by the ancients. In fact, the name Britannic Isles is derived from the two Phoenician words, Breta-nac, meaning land of tin.

It is evident that in early history there was confusion over bronze, brass, and other copper alloys, often resulting in the use of the word brass when copper or bronze was meant.

Apparently the first attempt to cast brass in the North American Colonies was in 1644 at Lynn, Mass. Brass cannon were cast in Philadelphia before the Revolution. In 1882 a brass business was established at Waterbury, Conn., for the purpose of making brass buttons, which was the first recorded instance in America of brass making by direct fusions of copper and zinc, and the undertaking also involved the first rolling of brass here.

The brochure devotes a good space to present day advanced methods of making brass, including a description and illustrations of the modern laboratory and research department which is responsible for future development. In the section on the characteristics of brass, additions and impurities and structure, are a number of instructive curves and photo-micrographs indicating the structure of brass which has been subjected to different amounts of cold rolling.

## LAND CLEARING AND CHEMISTRY.

W. R. JAMES in the *Chemical Age* for April, page 483, contributes an article on Clearing Cut-over Pine Lands of the South and Destructive Distillation of the Stumps, which affords another example of our dependence on chemistry and chemical engineering. The interest in this project originates in the possibilities of clearing land for agricultural purposes by the use of explosives produced by chemical methods primarily for other purposes. Even this quick way of dislodging stumps may be somewhat expensive and as the cleared land is the first consideration these stumps may be regarded as by-products of the first operation. Starting with the stumps as the raw material, the next step is their treatment by distillation for the production of charcoal, tar, and mixed tar oils. A careful study indicates that under favorable circumstances this utilization of the stumps could be made to more than pay for clearing the land, and one company has now begun operations on a 100,000-acre tract.

A plot of 25 acres was treated as a semi-commercial scale experiment and having been cut over twice in the past 15 years the stumps were some 6 to 15 years of age. 25 acres were cleared for a total cost of $780.04 and 124.1 tons of stumps were recovered at an average cost of $31.20 per acre or at $6.28 per ton. Care was taken in blowing the stumps so as not to leave deep holes. A horizontal retort of one cord capacity was used and two different schedules were employed for the sake of comparison. The 24-hour schedule gave 62.29 gallons of tar and oil and 463 pounds of charcoal per ton of wood distilled. The 36-hour schedule produced 76.4 gallons of tar and oil and 411 pounds of charcoal per ton of wood. Selling the oil for 18c a gallon and the charcoal at 1c a pound the operating profit was $12.33 per acre on the 24-hour schedule and $12.81 on the 36-hour schedule, the latter being due to the increased yield of tar and oil which offset the increase in labor and depreciation charges and decrease in charcoal.

Since the experiment was tried, the price of oil has advanced until nearly 30c per gallon can be realized. These mixed tar oils are in demand in the ore flotation process, as well as for insecticides, disinfectants, cattle dips, in the manufacture of insulation, paints, etc. Turpentine may be separated by redistillation, and rosin can also be recovered in such a wood reduction plant.

## LEATHER IN ENGINEERING.

IN the *Shoe and Leather Reporter* for February 26th, page 83, F. R. Parsons indicates the importance of leather in the British engineering trades. The efficiency and durability of leather depends to a great extent upon the care which is given it while in service and while not in use. Leather is called upon to show its durability when used in hydraulic pump insulations more than in any other place. The most carefully selected hides are used for this type of work. The leather must be durable and at the same time pliable and soft. Cup leathers, particularly, demand the best material. Leathers for this purpose must be cut from the best parts of the hides, and oil-dressed with care. In the writer's opinion, cup leathers pressed with the flesh side outward give the best results, although this is not uniform practice with those manufacturing such leathers. It is recommended that pump valves, barrel sweeps, etc., should be immersed in hot tallow, afterwards well rubbed into the leather with the hands before being put into service. Lubricating oil and mineral oils should never be used, but where cold water is to be handled vegetable oils, neat's-foot and sperm oil can be recommended.

Leather hose is still used to some extent on dredgers, though displaced by woven materials in most engineering operations. When such hose is used in salt water it requires frequent oiling or "nourishment."

To recondition leather it should be well washed and brushed with lukewarm, not hot, water and after drying a mixture of tallow and cod oil worked in with a stiff brush.

# Progress in the Field of Electricity

## Summaries and Excerpts from Current Periodicals

By A. Slobod

### PROPOSED 220,000-VOLT TRANSMISSION LINE FOR CALIFORNIA.

THE best available information indicates that the demand for power in California in 1926 will amount to about 1,040,000 kw. At present small developments aggregating 325,000 kw. have been completed; the rest will have to be supplied by the four hydroelectric projects, namely: Pit River, Feather River, Big Creek and Colorado River which are estimated to be able to deliver about 1,500,000 kw. in the near future. The economies of power supply requires that power be developed in large units, and large power units require transmission lines of the highest possible economic voltage.

It is proposed then to construct a two-circuit transmission system of 220,000 volts extending from Pit River to Los Angeles, a distance of 570 miles. Branch lines of like voltage connect the three other power projects and the San Francisco load center to this main line on which the other load centers are located. The main line thus becomes a high-tension bus extending nearly the entire length of the state, hence its name—California transmission bus. This arrangement makes possible unlimited interconnection and exchange between all the power companies of the state. Substations have been located at Marysville, Stockton, San Francisco, Fresno, Bakersfield and Los Angeles. These points are natural load centers and suitable points for connecting with the present power systems. The substations divide the lines into sections of suitable length for practical operation, the longest section being 150 miles.

It has been shown by Silver[1] that for long transmission 220,000 volts is economical under conditions which require a much more expensive construction than has proven adequate for the 150,000-volt lines of the Southern California Edison Co. The lines of this company would form a link of the proposed transmission bus and could be operated at 220,000 volts without material change. Sixty cycles would be the standard frequency, and the systems operating at 50 cycles will ultimately find it advantageous to conform to the A.I.E.E. standard. Under the proposed conditions the corona loss might amount to 8 per cent of the line capacity with storm conditions over the entire line. This loss is not sufficient to make the line inoperative and would occur too rarely to be an economic factor. For operating the Big Creek line at 220,000 volts it is proposed that suspension strings have 11 units and dead end strings 12 units in series.

The line capacity of the present system will greatly increase when operated at 220,000 volts. This is a fair indication of the conditions which will exist in the proposed system, the load centers of which are so distributed as to limit the actual average distance of transmission to about 200 miles. The economic gain in doubling the capacity of lines which cost approximately $6,000,000, the present cost of which would be at least 30 per cent more, would more than offset the cost of all necessary changes, including the adoption of the standard frequency. The mechanical features of the new line will not be much different from those of the Big Creek line which has proven entirely adequate for California conditions. Complete parallel operation of all lines must be adhered to in the proposed system. Satisfactory protective relay systems for dropping defective sections have been developed for present lines, and there appear to be no obstacles to extending these to the higher voltages.—R. W. SORENSON and others, *Engineering World*, February 1, 1920, pp. 127-30.

[1]Proceedings of the American Institute of Electrical Engineers, June, 1919.

### THERMIONIC VALVES.

AT a recent meeting of the western center of the Institution of Electrical Engineers a lecture on "Thermionic Valves" was delivered by Prof. Frederic Bacon. As a technical aid in winning the war the professor claims that the thermionic valve deserves as prominent a place as the tank or the paravane, but owing to the secrecy which has only just relaxed, and the highly technical nature of its applications, only imperfect accounts of it have received general publicity. In five or six years it has completely revolutionized wireless telegraphy, both as regards transmission and reception, and it has made wireless telephony a practical proposition. The system of the anti-submarine detection which appeared at the time of the armistice to be the only system inherently capable of providing a really effective solution of this most difficult and baffling problem, used 14 such valves of various kinds and sizes so as to discharge seven distinct functions. Towards the end of the war the output of thermionic valves in England alone had risen to the rate of half a million per annum. In 1914 practically all the most powerful transmitting stations in the world generated waves by sparks, and signals were received by means of crystal detectors, or magnetic detectors. To span 100 miles or more very large aerial structures were necessary both at the receiving and sending stations. Today most of the high power stations for long distance transmission use "continuous waves," i.e., they produce uniform uninterrupted waves instead of short gushes made by sparks. At the receiving end the faint incoming signals are amplified and detected by thermionic valves with such ease that an aerial is hardly required. For example, under favorable weather conditions, it is quite easy to listen to signals coming in from the other side of the Atlantic by using a circuit of which the receptive element merely consists of a small coil of wire some 3 or 4 feet square. From an article published in *Elektrotechnische Zeitschrift* it is possible to see that Germany started the war with a flying start of a year in the application of thermionic valves, but at the time of the armistice she had only arrived at the stage the allies reached in the spring of 1917.—*Colliery Guardian*, May 7, 1920.

### SAFETY DEVICES OF THE SAFETY CAR.

THE extension of the use of safety cars and the constant broadening of the field for them suggests the importance of familiarity with the various parts that constitute an equipment. Safety devices are essential to insure easy, safe and efficient operation of the one-man type of car. The cost of maintenance and the number of irritating troubles and delays which occur when such cars are introduced are influenced to a large extent by the familiarity which the operator and maintainer have with the new equipment. Most railways are unfamiliar with the new type of the apparatus developed for this service until they actually have them as an addition to their rolling stock.

The subject of the safety car equipment is therefore timely, hence with a view of giving the present or prospective user as clear an idea as possible of the functions of the various parts the author contributes a series of articles explaining the fundamental characteristics and the methods of care and operation which insure the proper functioning of the following features of the safety car:

1. The car cannot be started with the doors open because the brakes cannot be then released.

2. The doors cannot be opened without causing a brake application sufficient to stop the car.

3. Unintentional removal of the operator's hand from the controller handle will cause an application of the emergency brake.

4. The brakes cannot "leak off" while the car is standing with the doors open.

5. An automatic emergency application results if either of two pipes (emergency and safety control) running from platform to platform, is ruptured.

6. The doors are changed from air-operated to hand-operated whenever an emergency application of the brake valve is made.

7. The power is cut off, sand is applied and doors become hand-operated whenever an emergency application is caused by releasing the controller handle.

8. If excessive cylinder leakage causes a service application to "leak off" while changing hands an emergency application will result.

9. If the platform piping be ruptured by a collision an automatic emergency application will be obtained and the damaged piping will be so cut off as to prevent exhaustion of the main reservoir.

10. After a stop the controller handle must be pressed down before the brakes are released.

11. Ends cannot be changed without making a brake application before the operator leaves the operative end or an automatic emergency application results.

12. The sand is automatically applied in an emergency.

13. The safety features are obtained without increase in the number of manipulative handles.

14. The doors are air-operated.

15. Sanding is accomplished by air without the use of a special handle.

16. Provision is made for intentional and temporary release of the controller handle without emergency application resulting.

To sum up, the safety devices provide for successful operation of the safety car because they insure that the operation shall be safe, proper and easy; safe, because man failure is provided for; proper, because the operator's movements are so interlocked that they must be taken in the proper sequence, and easy—because the operator's labors are reduced to the minimum by the use of air-operated devices.

## USE OF ELECTRICITY IN METALLURGICAL PROCESSES.

THE development of electrometallurgical processes to a position of great industrial importance during the last decade was one of the noteworthy steps in the progress of metallurgy. In 1910 only 25 cities in the United States and Canada had electrometallurgical or electrochemical power loads; today total load of approximately 1,300,000 kva. used in electrochemical processes, electricity is used in the metallurgy of the following metals, either as a heating agent or for its electrolytic effect: pig iron, steel, cast iron, the ferro-alloys, aluminum, copper, brass, lead, zinc, gold and silver. There is a total load of approximately 1,300,000 kva. used in electrometallurgical processes in the United States and Canada, not including motor loads.

*Installed Power Capacity in Electrometallurgical Processes in the United States and Canada.*

| Process | Kva. Load | Process | Kva. Load |
|---|---|---|---|
| Pig iron | none | Brass | 23,000 |
| Steel | 600,000 | Lead | 1,400 |
| Ferro-alloys | 200,000 | Zinc | 60,000 |
| Aluminum | 350,000 | | |
| Copper | 45,000 | Gold and silver | 1,000 |

*Pig Iron.*—The electric smelting of iron ore is no longer in operation in this country; the plant at Heroult, California, was discontinued in 1914. It will hardly develop to any extent in this country because of the cost of power. On the other hand in Sweden and some other countries it has been steady as seen from the table below:

*Electric Furnaces Smelting Iron Ore.*

| Country | Type of Furnaces | Number of Furnaces | Sizes of Units Kva. | Transformer Capacity Kva. |
|---|---|---|---|---|
| Sweden | Shaft | 19 | 2,000 to 7,000 | 64,000 |
| Norway | Pit | 3 | 1,200 | 3,600 |
| Norway | Shaft | 1 | 3,000 | 3,000 |
| Switzerland | Shaft | 2 | 3,000 | 6,000 |
| Japan | Shaft | 2 | 3,000 | 6,000 |
| Italy | Shaft | 6 | 3,000 | 18,000 |

The power consumption is from 2,000 to 3,000 kw-hr. per ton, the lower figure being for white iron and the higher for grey iron. The electrode consumption varies from 13 to 20 lb. per ton of pig iron. The electrical load is very steady, and it should be possible to attain an average load factor of 80 per cent. During the war a considerable quantity of low phosphorus pig iron was made in this country and Canada by electric melting of steel scrap; there seems to be a future for this process, especially in foundries where the cost of pig iron is high due to freight. The metallurgy of synthetic electric furnace cast iron was worked out by C. A. Keller in France during the war. Other uses of the electric furnace are in refining gray iron from the cupola and in production of malleable castings. It has also been considered as a mixer for keeping molten blast furnace pig iron hot before casting into pipe.

*Steel.*—The increase of the use of electricity in steel production has been most phenomenal. In 1904 there were four small electric steel furnaces in Europe while the present number throughout the world is estimated at 875. The production of electric furnace steel in the United States in 1917 was 304,543 gross tons. Probably 1918 and 1919 will show a production of over 400,000 gross tons for each year. Almost 50 per cent of the 1917 production was alloy steel. Of the 323 furnaces in the United States 54.5 per cent are being used for making castings. The most marked development of the electric steel furnace has been the production of ingot alloy steels for automobile construction and high speed steel. A future probable large development is the use of the electric furnace for finishing molten converter and open hearth steel. An extensive installation for this purpose has been made by the Illinois Steel Company.

As a central station load the electric steel furnace gives the least desirable load of any of the uses of electricity mentioned in this paper. Yet it is a very desirable load although its load factor is low compared with that obtained in some other electrometallurgical processes. This is because most foundries operate on a ten-hour day instead of a twenty-four hour day. The central station should encourage then the twenty-four hour day by offering lower rates for continuous operation; the load factor will then vary from 40 to 55 per cent when making castings. A furnace refining molten steel should attain a load factor of 75 per cent on twenty-four hour operation.

The power consumption varies from 550 kw-hr. per ton when melting scrap on acid bottom for castings to 800 kw-hours per ton when making alloy steel ingots requiring refining. The voltage of the only type of single phase furnace now used is about 140 volts on the arc, 220 volts open circuit. On two and three-phase furnaces the voltage is from 90 to 110 volts. The electrode consumption is 15 to 25 lb. per ton of steel.

Another quite desirable load is the electric furnace for heat treatment of steel; the electric heat treatment of steel is cer-

tain to become common practice even at a higher cost because of the ease of control and uniformity of the results obtained. At present the carbon resistance type of furnace has been installed for this purpose. During the war another type was developed in which the heating unit consists of a calorite ribbon mounted on a cast iron supporting plate and insulated therefrom by suitable refractory material.

*Ferro-alloys.*—On January 1, 1920, there were in the United States and Canada forty plants with a combined transformer capacity of 200,000 kva. At present, however, 75 per cent of these plants are not operating. Many of them are in the hands of a receiver and will eventually be dismantled. Some electrical characteristics of electric ferro-alloy furnaces are given in table below:

ELECTRIC FERRO-ALLOY FURNACES

| Product | Size of Furnace Kva. | Phases Usual Type | Secondary Phase Voltage | Per Cent Power Factor | Per Cent Local Factor | Per Cent Overload Swing | Load Curve |
|---|---|---|---|---|---|---|---|
| Ferrosilicon..... | 750 to | 1 | 80 | 92 | 80–85 | 25 | Smooth |
| Ferrosilicon..... | 7,500 | 3 | 120 | 70 | 80–85 | 10 | Smooth |
| Ferromanganese. | 1,200 to | 3 | 65–75 | 85 | 80–85 | 10 | Very smooth |
| Ferromanganese. | 5,630 | 3 | 115–120 | 70 | 80–85 | 10 | Very smooth |
| Ferrochromium.. | 1,000 to | 3 | 67–75 | 95–90 | 80–85 | 25 | Smooth |
| Ferrochromium.. | 1,500 | 3 | 75 | 85–90 | 80–85 | 25 | Smooth |
| Ferrotungsten... | 75 to 250 | 1 to 3 | 55–75 | 90 | 50–70 | 50 | Irregular |
| Ferromolybdenum ...... | 75 to 250 | 1 | 55–75 | 90 | 50–70 | 50 | Irregular |
| Ferrovanadium.. | 150 to 500 | 1 | 55–75 | 90 | 70–80 | 25 | Smooth |
| Ferro-uraniumn. | 75 to 150 | 1 | 55–75 | 70 | 70–80 | 500–100 | Very irregular |
| Ferrotitanium... | 500 | 1 | 55 | 85 | 80 | 50 | Irregular |

The two most important developments have been the electric smelting of manganese ores and the increased use of molybdenum in steel. Probably 300 tons of ferro-molybdenum were produced in 1918 as compared with less than 25 tons in previous years. There was a very small production in 1919. The electric smelting load, at present time exemplified by ferro-alloy furnaces is probably one of the best loads a power company can get, and in the future may prove a much larger load with application of electricity to smelting of non-ferrous ores.

*Aluminum.*—This metal is now fourth in quantity of production of non-ferrous metals and in variety of uses is only surpassed by iron and copper. The practical metallurgy of aluminum has been kept as secret as possible. In one of the most recently constructed plants the furnaces or cells take 20,000 amperes of direct current at seven volts. Seventy of these furnaces are connected in series on a 500-volt, direct-current line. Power is supplied to the battery by a 10,000 kilowatt, direct-current generator direct driven by a water wheel. The power consumption is about 15 kw-hr. per pound of aluminum. The load is ideal for central stations. In addition to the use of electricity in the production of aluminum it is also used for melting aluminum in furnaces of resistance type. A carbon resistor furnace of 500 kw. capacity has been put on the market for this purpose.

*Copper.*—Since 1883 electricity has been used in this country to refine copper; at present there are nine electrolytic copper refineries in the United States. The greater part of them are located on New York harbor, and power is generated by steam in the power-plant of the refinery. Seven to eleven pounds of copper are deposited per kw-hr. The electrolytic deposition of copper from leaching plant solution is in practice on a large scale at Ajo, Arizona. As high as 2.5 lb. of copper have been deposited per kw-hr. An increasing quantity of electricity is being consumed in the large copper smelting plants for removing dust from smelter smoke. A new Cottrell smoke treatment plant has been completed at Anaconda which uses approximately 1,000 kw. The use of power will be increased until almost every smelting plant is equipped. The process is also being used on manganese and lead furnaces.

From the standpoint of the central station the most important development in the copper industry is the electric furnace for melting brass and non-ferrous metals; the number of these furnaces had grown to 261 on March 1, 1920. It is usually built in such small units that the fact that it is a single-phase should not prove seriously objectionable and should become an important load for the central station.

*Lead and Zinc.*—Electricity is used for the refining of lead bullion by the Betts process. Fifteen lb. of lead are deposited per kw-hr. Power is generally supplied at 90 to 115 volts, and the cells are connected in various arrangements. The commercial application of electrolytic precipitation of zinc from sulphate solution in the hydrometallurgy of zinc is less than five years old. At the present time there are four electrolytic zinc plants in the United States, with a total production capecity of 300 tons of zinc per day. One plant has been built in Australia and two in Tasmania. The secret of successful electrolytic precipitation is to precipitate the zinc from a pure electrolyte. Sheet lead anodes and sheet aluminum cathods are used. The power consumption in one plant is as low as 1.7 kw-hr. per lb. of zinc precipitated. While electric smelting of zinc ore and dross has been practiced commercially in Sweden since 1901, nothing has been done in commercial production in this country or Canada.

*Gold and Silver.*—Electrolytic refining of gold and silver bullion has been practiced for a number of years in the United States mints. It is also used in the refinery of one Perth Amboy smelting plant. The power involved in these installations does not exceed 500 kilowatts. Several electric melting furnaces were installed in the United States during the war which proved successful for melting silver dollars, nickel and copper.—ROBERT M. KEENEY, *Electric Journal*, May, 1920, p. 206-212.

## NEW ELECTRICAL EVAPORATING SYSTEM.

INSTEAD of evaporation by direct use of electric heating the closed-cycle equipment is urged as presenting many advantages. The evaporation takes place in a closed vessel. A steam coil is used to bring the charge of liquor to the boiling point. A compressor is then started, the vapor delivered through a pipe, compressed and then delivered to a worm where it is condensed and causes the evaporation of more liquor in the closed vessel. The hot condensate flowing from the worm is passed to the preheater where it preheats the incoming liquor. Finally, the cooled condensate issues as pure distilled water. This "autovapor" process offers a means of utilizing hydroelectric energy instead of coal; the latest "autovapor" installations evaporate 60 kg. per m². This compares very favorably with the rate of 3 to 5 kg. per m² of heating surface in the first closed-cycle equipments. The pressures used are from 0.1 to 1.5 kg. cm.² abs.

The following test data are given from a plant evaporating soda lye of from 5 per cent to 17 per cent. In the middle of the six hours required to effect the concentration the performance of the plant during one hour was: Km-hrs. supplied to driving motors, 54¼; pressure in evaporator, 1.29 kg./cm.² abs.; temperature of lye, 107.6°C.; temperature of condensate leaving feed water, 91.5°C.; live steam supplied, 100 kg.; water removed from lye by compressor, 1,070 kg.; water extracted per kw.-hr., 19.6 kg., excluding the live steam, or 18.0 kg. when allowing for the latter. Comparing these results with the heat equivalent of 1 kw-hr. it is evident that the evaporation is from 11 to 13 times that obtainable by direct electrical heating. The system is applied also to the concentration of sulphite lye and for other chemical purposes. By a slight increase in compression pressure an evaporation of 73 kg. per m² of heating surface can be obtained, the evaporation per kw-hr. decreasing only to 16 or 17 kg.—E. WIRTH, *Bull. Schweiz. Elektrot. Ver.*, December, 1919, Vol. 10, pp. 347-55.

# Survey of Progress in Mechanical Engineering

## Prepared Under the Auspices of the American Society of Mechanical Engineers

### OBTURATORS VERSUS PISTON RINGS.

Experiences in air-cooled engines on aircraft led in some cases to the replacement of the ordinary piston rings by an obturator, which is essentially the equivalent in metal of the cup leather used for packing hydraulic cylinders. The air-cooled cylinders of rotary engines, it was found, suffered distortion when at work owing to the leading side of the cylinder being more effectually cooled than the trailing side. As a consequence, piston rings often failed to hold the pressure, satisfactorily. Any increase in their number would have involved a longer and heavier piston, and the obturator was introduced in consequence. This, as explained in an interesting and valuable paper by Mr. W. Fennell, M.I.E.E., which was read at a recent meeting of the Diesel Engine Users' Association, consisted of a flexible L-shaped ring forced against the cylinder wall by fluid pressure. At the outset the life was short, but improvements made at the works of "Engineering and Arc Lamps" increased the life from 10 hours to 60 hours, and in exceptional cases to 250 hours. Brass was the metal first employed, but a special phosphor-bronze is now used. The obturator was placed near the top of the piston, but being flexible and forced by the pressure into close contact with the relatively cool wall of the liner it did not burn. Nevertheless, it is now considered preferable to fix it some little distance below the piston head. As originally fitted the rings were split similarly to a piston ring, but a lap joint is now used, and with this, the obturator works well, even if the liner be worn out of true. In consequence of the satisfactory behavior of these obturators, Mr. Fennell determined to fit one to a three O cylinder Sulzer-Diesel engine rated at 140 hp. The liners of this engine had worn badly, being far from circular and tapering to the extent of 1/10 in. It was impossible under the conditions to obtain new liners, and piston rings failed so rapidly that the engine could not be run save at a prohibitive cost. It was decided accordingly to fix the three top rings of the piston and to place an obturator in the fourth groove. After a run of 100 hours without loss or blowing by, the obturator was examined. The wear was less than 1 mil, and the engine was set to work again, without replacing it. This obturator lasted 380 hours and then failed, due to wear at the lap joint. Here the motion was considerable, owing to the taper of the liner. Further experiments showed that even with these badly-worn liners the obturator might be counted on to last 300 hours, which was longer than the piston rings would stand. Further tests are, Mr. Fennell stated, in progress, and they indicate that with the liners in proper condition the life of the obturator should be well over 1,000 hours.—*Engineering*, Vol. 109, No. 2833, April 16, 1920, p. 520.

### THE GENERAL TREND OF DIESEL MARINE MACHINERY.

According to an editorial in *Engineering*, there is at the present time no problem concerning the minds of our marine engineers to a greater extent than that of the application of the Diesel oil engine to marine propulsion.

Statistics, as far as they are available, and without any data as to German construction, show that in the field of ships of greater dead-weight capacity than 2,000 tons, considerably more than 150 are on order and in course of construction at the present time and destined to be fitted with marine Diesel engines.

In the list of countries where this kind of work is done Denmark occupies the first place, the United States of America the second, and Great Britain the third, but it is claimed that the position of Great Britain is rapidly being improved.

A review of the type of engine being constructed goes to show that the simple single-acting, 4-stroke cycle engine is largely preferred today, and of the vessels built only some 12 per cent are to be fitted with engines of the 2-stroke cycle type. Moreover, almost half of the 2-cycle engined ships are single screw, whereas 90 per cent of the 4-stroke cycle machinery is of the twin screw variety. Of all the motor vessels over 80 per cent are fitted with twin screws.

The 2-stroke cycle engines comprise the opposed piston types at present exclusively built in Britain, the supercharging port scavenging engine originated in Switzerland and being built now chiefly in Switzerland and Italy, and the valve scavenging engine which is now retained by only one French constructor. In America very few 2-cycle Diesel engines are in the course of construction, and Sweden, Denmark and Holland are solidly in favor of the 4-stroke cycle engine.

In Britain not only is the greatest variety of type evidenced, but also the largest engines are being constructed, the most powerful, the 4-cylinder opposed-piston two-stroke engine of 750 b.hp. per cylinder. The clyinder diameters are 580 mm. and the stroke 1,160 mm., and the engine develops, at 70 revolutions in the four cylinders, a total of 300 b.hp. The largest 4-cycle engine being constructed in Britain, and also elsewhere, has cylinder diameters of 740 mm. by a stroke of 1,150 mm., and runs at 115 r.p.m., developing over 3,500 b.hp. in eight cylinders. The 2-cycle engines are of four and six cylinders—generally of four cylinders— and the 4-cycle engines have six cylinders with a few exceptions where eight cylinders are employed to give the desired high power.

The British policy of trying out all types of engine is certain to lead in the end to a very favorable position, and is a very bold policy to be commended in view of the leeway which had to be made up and the lead unquestionably held by the earlier constructors of 4-cycle engines. The unfortunate and unlikely event of failure with any of the newer types cannot now, in view of the varied and long experience already piled up to the good, be taken as evidence sufficient to condemn this prime mover in respect of its suitability for marine work.—*Engineering*, Vol. 109, No. 2836, May 7, 1920, pp. 617-618.

### MECHANICAL SCREENLESS AIR FILTERS.

There are four ways of filtering air. One is to pass it through a screen so fine that the dust will be kept out. The second way is to pass it through a liquid, which, in this case, acts as a screen of infinitely fine mesh. The third method is to pass the air through an electrical screen, the mesh of which is constituted by lines of electric force. This is the Cottrell system of dust precipitation which is very effective under certain conditions. The fourth way is to interpose in the path of the flowing air mechanical obstacles which will not interfere to any very material effect with the flow of air itself, but will cause precipitation or separation of the heavier particles such as dust. A number of devices belonging to this fourth class are described in the present article.

In the air filter of the Balcke Machine Co. of Bochum, Germany, Fig. 1, the air flows between several rows of vertical wooden planks staggered and located at angles of 45 deg., with respect to each other, as shown in the drawing. Because

of the frequent changes of direction the dust particles are projected against the wooden planks and washed off them by the water flowing over their faces. Because of this arrangement, it is necessary to clean the planks. Fig. 2 shows a Balcke cleaner capable of handling 24,000 cu.m. of air per minute.

Water is raised to the top of the cleaner by pump A and is distributed over the planks N by the trough B and hopper C. The water is accumulated at D and may be used for purposes where the presence of dirt in the water is not injurious.

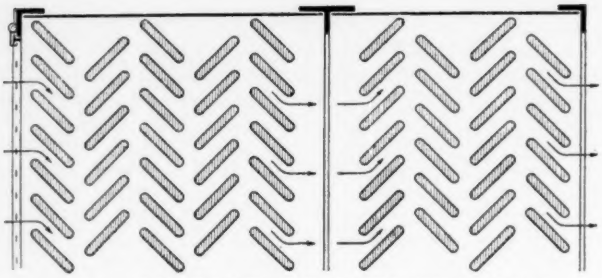

FIG. 1. BALCKE AIR FILTER (SECTION THROUGH THE PLANKS)

Back of the wet planks N are located several rows of dry planks T, the purpose of which is to catch the water particles carried off from the wet half of the filter. It has been found in practice that these planks remain very nearly dry, a good indication that the use of the wet filter causes only an insignificant increase in the humidity of the air. Measurements have shown that with fairly dry entering air there is an increase of humidity of from 3 to 6 per cent, and when the humidity of the entering air is considerable, there is practically no increase of humidity.

Air filters of this type are mainly used for cleaning air employed for purposes of cooling, since there the variation of humidity is of lesser importance than, for example, with air compressors. As advantages for this type of filter are claimed the low resistance in the filter, the elimination of filter cleaning and the absence of fire danger from the accumulation of dry dust.

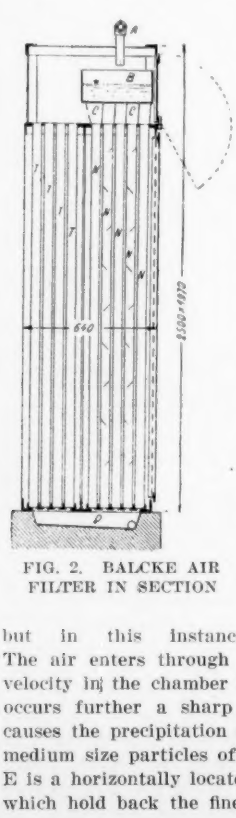

FIG. 2. BALCKE AIR FILTER IN SECTION

The next mechanical air filter described is the Viscin filter of the German Air Filter Construction Co. of Berlin. The active part of the Viscin filter consists of a frame filled with so-called Rachig rings of about 14 mm. height and the same diameter. These rings are wetted with a liquid called Viscinol, which is claimed to be very sticky and little subject to deterioration. This type is not described in detail as its operation is evidently dependent on the use of a particular liquid employed for wetting the rings.

The Moeller filter (Fig. 3) built by K. and Th. Moeller of Brackwede, Germany, consists also of a frame filled with Rachig rings, but in this instance the rings are not wetted. The air enters through a perforated sheet iron wall A, its velocity in the chamber B is considerably reduced and there occurs further a sharp change in direction of flow which causes the precipitation of the larger particles of dust. The medium size particles of dust are held back by the screen C. E is a horizontally located container, filled with Rachig rings which hold back the finest particles of dust. The air comes out at F. Because of the three-stage method of separating the dust, namely, at D, C and E, a high degree of filtering is obtained notwithstanding the fact that no wetting of rings is resorted to. On the other hand, the dimensions of the air filter have to be made larger than in wet filters. Also the filters have to be cleaned every two or three months.

Strictly speaking, the Moeller filter does not belong to the class of screenless filters as a screen is used. It performs, however, a secondary function.—Stofflose Luftfilter, by Ernst Preger, *Werkstatts Technik*, Vol. 14, No. 3, Feb. 1, 1920, pp. 71-73.

## CHANTRAINE METALLURGICAL FURNACES

DESCRIPTION of the new type of furnace in which combustion is carried on by means of a large number of separate jets of fire.

In conventional metallurgical furnaces the firing is effected by means of flame obtained through a simultaneous admission of the air and gas. With these systems the high temperatures needed for the metallurgical process can be maintained only in certain definite sections of the furnace, which, because of this, has a very variable regime throughout the combustion chamber and this leads to trouble, both as a result of the irregularity of distribution of heat and because of oxidation. It is claimed that the system described in this article, which the author calls "polymultiple" flame combustion avoids these defects.

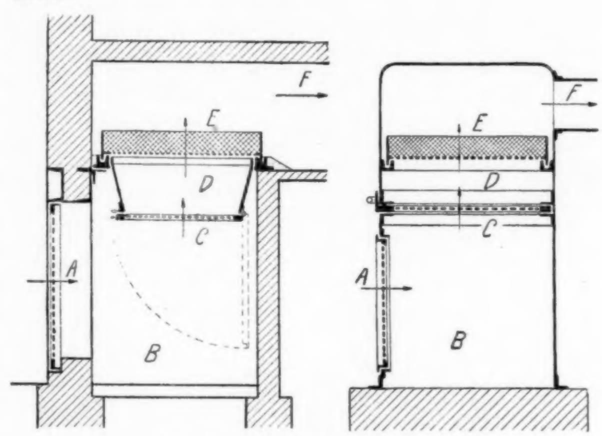


FIG. 3. MOELLER AIR FILTER

The following are the characteristic features of the Chantraine method:

1. The reservoir of hot air usually produced by making the roof of the combustion chamber double and providing for an interspace through which pass the conduits leading the air to the combustion chamber from the hot air recuperator.

2. A number of orifices provided in the lower roof of the hot air reservoir, these orifices acting as tuyeres to admit the air to the combustion chamber.

3. A sheet of combustible gas floating under the perforated roof of the combustion chamber; this sheet of gas is fed in solely and continuously through gas conduits from the gas producers.

4. A continuous apparatus for recuperating the combustion chamber waste heat employed for a preliminary preheating of the secondary air.

The operation of the system is based essentially upon the following: The air under pressure whether natural or artificial passes through the multiple tuyers and then through the sheet of gas solely and continuously fed to the roof of the combustion chamber; in doing this, the air creates a bundle of flaming darts, a compact bundle directed towards the material to be heated. The products of combustion are exhausted solely by the pressure in the combustion chamber.

The theory of this system of combustion is as follows: If a

jet of gas passes into the air as happens in conventional systems, combustion occurs on the periphery of this jet and this periphery produces heat radiation, the majority of which pass into the air which is diathermos while the commercial combustible gas is athermos.

On the other hand, if a jet of air is made to penetrate into the atmosphere of ordinary combustible gas so as to produce the same number of calories per second, the periphery of the jet also emits heat and light radiations and a great

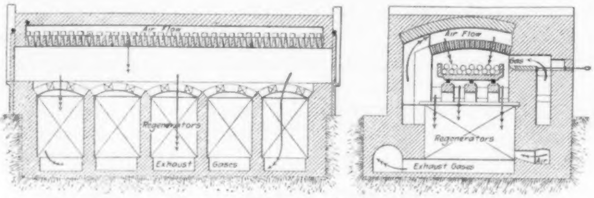


FIG. 4. CHANTRAINE "POLYMULTIPLE FLAME" METALLURGICAL FURNACE

majority of the heat radiations go into the air of the jet preheating it all the more the less air there remains for the oxidation of the gas, which latter is athermos. As a result of this, the tip of the flame of air in a gas atmosphere is many times hotter than the tip of the flame of gas in an air atmosphere and the combustion even with the low initial temperature is practically perfect with the minimum excess of air, while in the opposite process (a jet of gas going into the atmosphere) the excess of air must be very large.

Furthermore, in conventional furnaces the radiation spreads equally on to the roof and the side walls as well as on the floor of the furnace and the matter located thereon. In polymultiple flame furnaces, the sheet of gas floating against the roof protects it as well as the walls against the radiations from the bottom of the furnace and the welding material. Also since the roof of the furnace is equipped with a number of orifices through which the constant flow of air takes place, the refractory material of the roof is never permitted to attain a temperature high enough to soften it or weld it.

The uniformity of temperature distribution in the furnace is secured because each jet projects on to the part of the flow whereon it radiates a certain number of calories.

The analysis of exhaust gases obtained when this system was employed for given contents of carbon dioxide very closely approaches the theoretical maximum. This fact is explained in the following manner. As the tips of the jets of air are very highly superheated, they use up all the oxygen which they contain during the passage through the fairly stagnant and thick sheet of combustible gas, the temperature of which grows as the flame nears the flow of the furnace.

Fig. 4 shows the general construction of the Chantraine furnaces.

As regards the temperatures obtainable with this system, it is stated that the temperatures at the tip of the individual jets are closed to the theoretical temperature of combustion. Since the jets cannot radiate their heat through the sheet of gas through which the air flows all the heat is retained and is used to raise the final temperature of combustion.

In ordinary furnaces a certain amount of metal is used through oxidation. In the Chantraine system the metal is separated from the oxidizing agents by a thick and uninterrupted sheet of neutral gases (products of combustion) the oxygen of which has been completely neutralized during the passage of the flame through a very hot sheet of reducing gases. This oxygen itself having been heated to an exceedingly high temperature. Furthermore, the pressure existing in the combustion chamber prevents the possibility of the entrance of outside air. It is claimed that fuel economy as compared with conventional types of furnaces may be secured as high as 40 per cent with lower metal losses, lower maintenance costs. This construction is particularly suitable for reheating furnaces, for steel melting furnaces, etc.—*Le Genie Civil*, Vol. 76, No. 14, April 3, 1920, pp. 336-337.

## THRUST BORING IN EARTH

DESCRIPTION of a machine invented by Capt. A. R. Mangnall and made by a British company. It is claimed that this machine will pierce a hole 4 in. in diameter and 150 ft. long horizontally through heavy clay in half an hour. It is intended for cable laying, pipe laying, drainage or similar work. The machine is in a sense an outcome of the war. Several attempts were made to devise an apparatus which could be started from our own trenches and bore under those of the enemy holes for mining and counter mining. The action of the machine can best be compared with that of thrusting a stick into clay. The machine consists of a hydraulic cylinder of steel tube, carried on trunnions in a light steel frame. Inside the cylinder is a short piston with hinged guiding fingers.

This "gun" complete on its framework is dropped into a pit dug into the ground to the depth required, a plate at the back of the framework or carriage pressing against a few timbers to distribute the load. The cylinder is connected by flexible pressure pipes to a little three-throw pump driven by a gasoline engine. The exhaust water returns to the sump from which the pump draws. The operation of thrust boring is begun by turning the gun up to a vertical position and dropping the "pilot" into it. The gun is then turned down and clamped in position, and hydraulic pressure is admitted behind the piston, pressing the pilot horizontally into the soil. The stroke being completed, the admission valve is closed and the exhaust valve opened—by one and the same lever—the gun is raised to the vertical and the first extension piece pressed into it. The exhaust water is then returned to the sump. The three guide fingers referred to keep the base of the extension piece in a central position. The

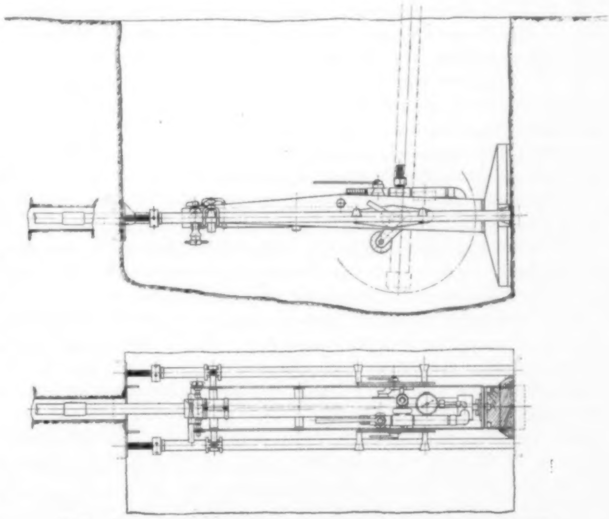

FIG. 5. MANGNALL EARTH THRUST BORER—SIDE ELEVATION AND PLAN VIEW

gun is again placed horizontally, and the extension piece is attached to the end of the pilot by a simple pin joint. The pressure is put on again, and the pilot driven forward another four feet. Then the same operation is repeated, extension piece after extension piece being added until the pilot breaks through into a pit at the far end—150 feet away. The pilot is then uncoupled and lifted out of the pit, and the extension pieces are withdrawn and uncoupled one by one. The whole operation of raising the gun, inserting an extension piece, lowering the gun, fixing the pin point, and thrusting the piece home occupies less than one minute.

The joint is extremely simple and ingenious. The extension pieces are tubes about 2½ in. diameter for a 4-in. hole, with muff couplings at the leading end. Through each coupling is drilled a pair of opposite holes; through the other end of each piece is drilled a corresponding pair of holes, but of smaller diameter. The pins are turned to fit the smaller holes freely, but at each end are reduced in diameter so as to leave a shoulder. The operator brings the holes opposite each other, slips the pin in position, and dabs a little bit of clay round the end. It is found that the clay locks the pins effectively, and that they never fall out. The withdrawal of the extension pieces is easy, since their diameter is a good deal less than that of the hole. The method generally employed is to attach a rope to the last piece and carry it round a pulley. Two or three men on the surface can then pull the whole chain of extension pieces back until the next joint is reached. The operation is repeated until the operator in the pit can pull the rods back without assistance. An alternative method is to turn the gun up to a vertical position, and by means of suitably arranged ropes and pulleys employ it like the cylinder of an hydraulic crane.—*The Engineer*, Vol. 109, No. 3354, April 9, 1920, pp. 369-371 and 376.

# Progress in Mining and Metallurgy

## Abstracts of Papers To Be Read at the Fall Meetings of the A. I. M. M. E.

### Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

### NATURE OF COAL.

BY J. E. HACKFORD.

IN some experiments conducted on petroleum and derived bitumens, results have been obtained which bear on the fundamental nature and origin of coal and the relationship between coal and petroleum.

The elucidation of the nature of a body like coal that is only sparingly soluble in solvents and cannot be made to yield crystalline derivatives without previous violent manipulation has naturally presented no little difficulty. During the past five years a large amount of work respecting the nature of coal has been accomplished by numerous investigators.

These investigations have been mainly along two lines, one, the examination of solvent extracts, and the other, the study of the products of low-temperature distillation. Briefly, these investigators have shown:

1. That by low-temperature distillation, and by the examination of solvent extracts, paraffine, olefines, and naphthenes have been isolated and identified.
2. That the tar distilled from coal at high temperatures is a decomposition product of coal tars previously formed at low temperatures.
3. That the cellulosic compounds present in coal result in the formation of phenols upon dry distillation.
4. That the temperature at which coal was formed cannot have approached 300°C.

The following theory as to the mode of formation and nature of coal is put forward, comparing it at the same time, for the sake of clearness, with the mode of formation of oil.

First, consider a stratum containing a deposit of either animal remains or marine vegetation. These substances, on decomposition, form oil and gas which, if contained in a sandy bed, are swept away from their source by either gravity or water as rapidly as formed, since neither the animal remains nor the marine vegetation contain cellulosic material capable of forming a spongelike mass, which would hold the oil *in situ* during the composition stage.

Secondly, assume a buried deposit of terrestrial vegetation. Decomposition takes place, resulting in the formation of oil and gas, as in the case of the marine vegetation. However, owing to the cellulosic nature of the material and its porous, spongy nature, the oil is kept *in situ* while decomposition proceeds. Accompanying this decomposition, there is probably a rise in temperature, which even if not above 100°C., is quite sufficient, as we have proved in the laboratory, to convert into kerotenes the oxy- or thioasphaltenes that are simultaneously formed with the oil. As the process goes on, the kerotenes become more and more insoluble until they are insoluble in pyridine and quinoline and so remain as a solid in the spongelike mass afforded by the cellulosic structure of the terrestrial vegetation.

The main differences between the so-called coals and true coal rests in the fact that they possess no cellulosic residue, which upon distillation can produce phenols, as in the case in true coals. It is conceivable that a kerite produced from microscopic vegetal remains containing some cellulose—but not in sufficient quantities to act as a sponge—would yield phenols on dry distillation; this would be but another connecting link between coal and petroleum.

Petroleum oils, such as occur in nature, are clearly not derived from coal; but given a quantity of vegetal material, petroleum may be produced under a given set of circumstances if no cellulose is present and coal will be formed if the vegetal matter contains sufficient cellulose to form a sponge.—To be presented at St. Louis Meeting, August, 1920.

### MODERN COMMERCIAL EXPLOSIVES AND THEIR USES.

BY A. J. STRANE, E.M.

EXPLOSIVES may be classified as those that burn and those that detonate. Explosives of the first class include black blasting and smokeless powder, and are broadly known as low explosives, or propellants, because they merely burn and do that comparatively slowly. Their action is as if some power behind the projectile or other material were exerting a shoving or pushing action. The high, or detonating, explosives produce a smashing or shattering effect upon the material.

In using military explosives of the propellant class, the breach of the gun, or cannon, is proportioned to hold the pressure, so that the projectile will be blown out. Exactly the reverse is true in commercial work; then it is the "breach" or the hole that is to be broken. Therefore, the projectile and the explosive that will rupture the largest "breach" possible are chosen. With the high explosives, it is easy to break out the breach, but with some of the low explosives it is necessary to plug up the muzzle very carefully before shooting.

Doubtless the use of incendiary mixtures of oxidizing and combustible materials led, in the 13th century, to the perfection of the mixture which is practically the same as our commercial black blasting powder of today. About 600 years later, nitroglycerine was discovered, but for years its great potential energy could not be used because, in its liquid state, it could not be safely handled or transported. The accidental discovery that kieselguhr would absorb, and hold fairly well, three times its own weight of nitroglycerine, however, made it available.

"Guhr dynamite," as the combination nitroglycerine and kieselguhr was termed, was soon displaced by dynamites having an active base, such as wood pulp and other carbonaceous combustible materials. These do all that kieselguhr will do and, in addition, increase the chemical reaction and add materially to the effectiveness of the blast.

An accident is said to have led to the discovery that gun-

cotton will cause the solidifying or gelatinization of nitroglycerine under certain conditions. This discovery gave us "blasting gelatine," which is taken as the standard for *100 per cent explosive* since its composition is practically 92 parts nitroglycerine and 8 parts guncotton, with a small amount of antacid.

The commercial explosives of today are: Nitroglycerine; blasting gelatine; straight nitroglycerine dynamites of various strengths; straight nitroglycerine gelatines of various strengths; extra or ammonia dynamites and gelatines of various strengths; low-freezing explosives of the above grades; permissible explosives, or coal-mine powders, of various strengths and physical properties; miscellaneous explosives, having special advantages for special work; non-freezing or non-nitroglycerine explosives; and black blasting powder of various sizes.—To be presented at Lake Superior Meeting, Aug. 23-28, 1920.

## A REFLECTING MICROSCOPE FOR THE MINING ENGINEER.

By W. MYRON DAVY, D.Sc.

FOR more than a decade the use of the metallographic microscope for examining ores has been increasing, but most mining men have been slow to realize the positive value of this instrument in their daily work, because simple and easily applied directions and, what is more important, light, compact, and inexpensive equipment have not been available. The simplest microscope obtainable is intended for laboratory use and is much too bulky for the average field equipment; at present it costs about one hundred dollars for the instrument alone. Methods previously described for polishing specimens have necessitated electrically driven lap wheels, which are found only in permanent installations. It is small wonder that the subject has been looked upon as being too involved for the field.

To overcome the difficulties enumerated, the author has designed an outfit that has proved very useful. It consists of a microscope, which is of the simplest construction and which weighs complete only 8 ounces. The magnification obtainable is about 75 diameters, which has been found to be well suited to average work of all kinds; but this can be varied within wide limits by changes in the ocular and objective, which are of the general type common in most metallographic microscopes.

### POLISHING THE SPECIMEN.

The materials for hand polishing include a coarse carborundum grinding stone, a square plate of glass, linen, a chamois-covered block, and tins of polishing powders. The entire outfit is compactly packed into a small case, which forms a handily included piece of field equipment.

To prepare a specimen for examination, a surface ½ to 1 inch square is chipped as flat as is convenient with a hammer and then ground to a plane surface upon the cutting stone. All grinding and polishing, except on leather, is done wet, care being taken that the specimen does not become heated because the sulfides undergo alteration under the heat of excessive friction. All rubbing is done in a circular path to prevent parallel scratching and grooving of both the specimen and the polishing surface. After careful washing, the specimen is ground upon the plate glass, using a thin paste of optical alundum (the finest artificial abrasive) and water.

### EXAMINATION OF THE SPECIMEN.

For examination, the polished specimen is pushed into the lump of modeling clay in the leveling tube. The tube, with its base, clay, and specimen, is inverted and pushed firmly down on any level surface, thus bringing the polished section flush with the top of the surrounding tube.

Tests for hardness, sectility, color of powder, chemical behavior, etc., may be applied. The microchemical tests are by far the most important and should be applied with care and uniformity. The reagents used in identifying the minerals on a polished surface are:

$HNO_3$, one part concentrated acid (sp. gr. = 1.42) and one part water.

HCl, one part concentrated acid (sp. gr. = 1.19) and one part water.

KCN, 20 per cent solution in water.

$FeCl_3$, 20 per cent solution in water.

$HgCl_2$, saturated solution in water.

KOH, saturated solution in water. These reagents are conveniently applied to the polished surface by the use of a pipette with a fine capillary opening and fitted with a small rubber bulb.

### APPLICATION OF THE FIELD MICROSCOPE.

This outfit finds its most useful application among mining engineers and geologists in the examination of ores. Complex sulfide ores consisting of several finely intergrown minerals are common and the identity and relations of these minerals can be determined only with the reflecting microscope. It may be argued that an exact knowledge of the mineralogical composition is unessential to a mining man, but the thinking engineer wants all the facts possible upon which to formulate his working theories. The examination of a few well-chosen polished sections may reveal the nature of the processes that have deposited or altered and enriched a deposit which could be determined by no other method of investigation. Such knowledge of the processes of ore deposition, both primary and secondary must form the basis for every intelligent system of development.

A rapidly growing field of application for microscopic equipment is that of milling and concentrating. Tests of new ores to determine proper treatment are conducted in the dark, due to imperfect knowledge of the character of the material treated. Ore dressers can direct work with greater precision and despatch if they know the exact nature of the ore, the identity of each mineral, and consequently the distribution of each metal, the relation of the minerals to each other, and the maximum, minimum, and average size of grain of each constituent.

Furthermore, at any point on the flow sheet the exact character of the concentrate, middling, or tails produced can be determined with ease by sprinkling the powdered material upon a piece of paper, covering with molten sealing wax, and polishing as any other specimen. This true cross-section of the grains will yield an accurate estimate of the size and proportions of included particles, if such are present, and the outline of each separate mineral is clearly distinguishable, though a microscopic grain be an intergrowth of several constituents.—To be presented at Lake Superior Meeting, Aug. 23-28, 1920.

## EFFICIENCY OF USE OF OIL AS FUEL.

By W. N. BEST.

THIS paper is not intended as a scientific discussion of the combustion of oil but is written from the standpoint of an operator who has the experience and qualifications necessary to guide others in producing the most economic results in the use of liquid fuels. In this paper, oil usually means petroleum or its products, but incidental reference is made to all liquid and gaseous fuels, so that the term may be considered as referring to all liquid and gaseous hydrocarbons in comparison with solid fuels, as coal and wood.

In New England and along the Atlantic coast, where the boiler horse-power is large, oil fuel is very attractive, for one man can fire and water-tend twelve 300 hp. boilers. This fuel responds immediately to the will of the operator in meeting peak or fluctuating loads. The fire room is clean and sanitary, dust from coal and ashes being eliminated. There is practically no loss in fuel, as only a small part of the oil in

the storage tank is heated, and that just enough for it to be pumped readily from the storage tank to the supply tank. The handling of the fuel is inexpensive, and it is speedily delivered from the oil tank or tanker. There are, however, certain fundamental principles that must always be observed in making crude-oil installations.

The temperature of the fuel and the method of supply are especially vital points. Oil below 20° Bé should be heated to just below its vaporizing point; steam should always be used for this purpose, as it gives a very accurate temperature. Thermometers should always be used, for heating fuel accurately and uniformly every day results in the greatest efficiency.

Supply lines should be so laid as to insure the constant circulation of fuel through all the oil-supply pipes from the pump to the burners. A pressure relief valve should always be placed at the farther end of the burner installation, and the overflow pipe should always return the unused fuel to the supply tank.

### TYPES OF BURNERS.

Numerous oil burners are on the market but the three types most common are: The external atomizing type, which is largely used in locomotive and stationary boilers and in large furnaces; the internal atomizing type, which is chiefly used on small furnaces; and the mechanical type of burner used on ocean-going vessels, requiring no steam for atomizing, which forces the oil at high pressure through a small aperture, thus making a funnel shaped flame.

When purchasing atomizing burners, several points should always be considered.

1. The burner must not carbonize. A burner that carbonizes should be scrapped at once, as it is not dependable, is wasteful of oil, and requires a great deal of care and attention. Such a burner reduces the burning of oil from a science to a continuous hazard and care.

2. The oil and steam orifices should be independent of each other so that excessive oil pressure is not required, and in order that no cutting effect is produced when burning oil containing residuum or sand.

3. The burner should be so constructed and filed that it will produce a flame of sufficient length and width to fill the combustion chamber of the furnace or firebox of boiler; just as perfectly as a drawer fits into its opening in a desk.

4. The oil surface should be large enough to permit free exit of heavy oils and tars therefrom, and the atomizer opening should be as small as possible in order to reduce to a minimum the amount of steam or compressed air used for the atomization of the fuel.—To be presented at St. Louis Meeting, August, 1920.

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# Correspondence

**The editor is not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.**

## THE ORIGIN OF VOLCANOES.

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

In the April number of the SCIENTIFIC MONTHLY there is an article, "The Ballistics of Volcanoes" with which I disagree and the reasons for which are submitted herewith. The theory that the steam from volcanoes is due to the penetration of sea water into highly heated or molten rocks is a fallacy because the resulting steam could never have greater pressure than the weight of the column of water and volcanic pressures greatly exceed this. Also the specific heat of the water is so much (five times) greater than the rock that the heat could not be extracted from the rock without cooling five times the weight of rock, which would certainly prevent fusing any of the remainder portion. The article entitled "Is the Earth Expanding or Contracting?" published in the May number of *Popular Astronomy* [*This is republished on page 7 of this issue.*—ED.] will give a more probable solution of the volcanic problem.

The pit craters on the moon are certainly not formed in the manner suggested by the sketch on page 295 because ejected matter falls near the crater and especially the coarse material, and builds up a cone instead of a pit as indicated. The pit crater rings on the moon and also the Halemaumau pit on Kilauea are formed in the manner shown in the accompanying sketches.

Sounding taken at the active pit in Kilauea have shown that it is very shallow except at the points where the gases are fountaining and causing the greatest amount of agitation. The gases are evidently the source of the heat which keeps the lava molten and in circulation in the pit. The same lava is caused to move around and round in the pit and does not overflow the rim of the pit except at the times of unusual escape of large amounts of gas. These gases according to analysis published in July, 1919, *Bulletin of the Hawaiian Volcano Observatory,* were on the average over 75 per cent water but the water is not of marine origin as shown by its composition. Also how could steam generated from sea water at sea level lift lava up to the crater in Kilauea 4,000 feet above sea level. The thing is absurd and impossible.

Photographs of the moon show large members of these pit craters which are of immense size as compared to the few known on the earth. The reason for this is that erosion has cut down the craters on the earth and the material at present on the surface has been worked over 20 to 30 times as shown by Salisbury in the *Journal of Geology* to get the amount of salt at present in the sea. Salisbury estimated that 20 to 30 times the amount of the continental masses above sea


FIG. 1. CIRCULATION OF LAVA DUE TO HEAT OF GASES

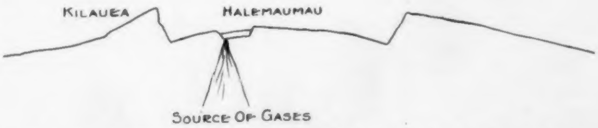


FIG. 2. SECTIONAL VIEW, SHOWING THE HALEMAUMAU PIT ON KILAUEA

level would be required to yield the salt in the sea. Attention is called to the large unnamed crater ring 500 x 650 miles in the moon of which the Apennines and Alps are a part and Mare Imbrium is the floor. The smoothness of these crater floors indicates a high degree of fluidity and points to a time when the whole surface of the moon was incandescent. Small crater rings inside larger ones indicate a progressive decline in volcanic action as the supply of gas was exhausted and the absence of an atmosphere on the moon is probably due to lack of gravitational pull sufficient to overcome the atomic energy of the gases. At all events the moon shows no signs of ever being subject to erosion.

New York. HIRAM W. HIXON.